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ABSTRACT OF THE DISSERTATION

Patterns in the Recall of Persons

by

Devon Duffield Brewer

Doctor of Philosophy in Social Science

University of California, Irvine, 1994

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This dissertation describes three studies on the organization of persons in memory. Individuals in a graduate academic program, a Taiwanese Christian fellowship, and a public affairs department of a university free listed the names of persons in their respective communities. Three types of response patterning were examined in subjects' recalls: association, frequency, and serial order. Associative patterns refer to the connections or relationships between adjacently recalled persons. Frequency patterns refer to which persons are recalled, and serial order patterns refer to which persons are remembered earlier or later in recall.

In the graduate academic program, subjects tended to cluster (mention adjacently) persons in recall by cohort (year in the program). Subjects' frequency and serial order patterns showed that persons in cohorts chronologically

close to a subject were more likely recalled and recalled earlier than persons chronologically distant from a subject.

In the religious fellowship, subjects clustered persons in terms of perceived social proximity. That is, pairs of persons recalled adjacently by a subject were perceived to be much closer socially than would be expected by chance. Regarding frequency patterns, the persons recalled by a subject tended to be socially closer to that subject and more visible in the fellowship than those persons not recalled. Subjects' serial order patterns demonstrated that more visible persons tended to be recalled earlier than less visible persons.

In the public affairs department, subjects clustered persons by perceived work proximity. In other words, pairs of persons recalled adjacently by a subject were perceived to work more closely with each other than would be expected by chance. Subjects' frequency and serial order patterns showed that the persons most likely recalled were the most visible in terms of regular physical presence and that higher status persons tended to be recalled earlier than lower status persons. In these studies, pairs of adjacently recalled persons were mentioned most rapidly in succession if they were in the same cohort, perceived to be socially close, and perceived to work closely, respectively.

This research indicates that the underlying cognitive structure of persons in a community is based on the community's social structure.

SOCIAL
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An International Journal of Structural Analysis

Patterns in the recall of persons in a student community *

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SOCIAL NETWORKS

Scope

   Social Networks is an interdisciplinary and international quarterly. It provides a common forum for representatives of anthropology, sociology, history, social psychology, political science, human geography, biology, economics, communications science and other disciplines who share an interest in the study of the structure of human relations and associations that may be expressed in network form. It publishes both theoretical and substantive papers. Critical reviews of major theoretical or methodological approaches using the notion of networks in the analysis of human behavior are also welcome, as are reviews of recent books dealing with social networks and social structure.

   There are no restrictions on the kinds of papers dealing with social networks that will be considered for publication. Acceptable papers may range from abstract formal mathematical derivations to concrete descriptive case studies of particular social networks. In every case, the editorial criteria for acceptance will be based on the degree to which a paper makes a broad theoretical or methodological contribution to the study of social networks. The editors are therefore particularly interested in papers that attempt to uncover the processes by which social networks emerge, evolve and have consequences for other aspects of human behavior.

Patterns in the recall of persons in a student community *

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This paper reports on the patterns in the recall of persons in a contemporary, socially bounded community. The associative, serial order, and frequency response patterns in the free recall of persons' names among students in a graduate academic program were found to be based on the program's cohort structure. Several observations on patterns in the recall of persons' names in this community paralleled findings from research on the recall of lexical items. The results suggested that individual informants' different positions in the cohort structure produced systematic variation in social knowledge of fellow students.

This paper investigates patterns in the recall of the names of persons in a contemporary, socially bounded community by people who are members of that community. The recall of persons' names is a relatively unexplored area of research. Although the recall of persons' names may involve influences not present in the recall of other stimuli, some general principles of memory may still be common to both kinds of recall. There is a long tradition in cognitive psychology of using free recall to study the organization of memory. Since experience with a given set of stimuli has been suggested as the basis for organization in memory (e.g. Mandler 1979), it would be expected that current members of a socially bounded community would have organized cognitive representations of community members as revealed in the free recall of community members' names. Furthermore,

to the extent that individuals have similar experiences with others in the community, community members should have common patterns in their recall of persons' names.

There are three types of response patterning in the recall of persons' names that will be examined: association, frequency, and serial order. Associative patterns occur to the extent that persons recalled consecutively tend to be more related to each other in some way (e.g. by social interaction or sharing some individual characteristic such as gender) than persons not recalled consecutively. Frequency patterns refer to differences in the likelihood that particular persons or some types of persons are recalled. Serial order patterns are tendencies for particular persons or some types of persons to be remembered earlier or later in recall.

After reviewing the literature that relates to each of these three types of response patterns in the recall of persons' names, [1] this paper examines the associative, serial order, and frequency patterns in the recall of persons' names among members of a graduate student community.

Associative patterns

Research on the free recall of lexical items demonstrates the generality of associative structures and processes in memory. Semantic clustering, or the tendency for semantically related items to occur together (adjacently) in free recall, has been widely documented in several variations of the free recall task and for different word list types (e.g. Bousfield 1953, Mandler 1970, Romney *et al.* 1993, Schwartz and Humphreys 1973) and observed cross-culturally (e.g. Scribner 1974), in two-year-old children (Rossi and Rossi 1965), in deaf subjects (Liben *et al.* 1978), and in a chimpanzee (Buchanan *et al.* 1981). In contrast to semantic clustering, other research indicates that the alphabetic/acoustic similarity of words does not play a role in organizing free recall when there is some sort of semantic organization to

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[1] Organization in the recall of famous persons has also been studied (Robertson 1990, Robertson and Ellis 1987, Roediger and Crowder 1976, Riegel 1973), but this research will not be discussed here because the persons recalled in these studies were not personally known to the subjects or connected to the subjects by common community membership.

the word lists recalled and has only a very minor effect when no such organization is present (Dolinsky 1972, Lauer and Battig 1972). Semantic similarity, then, seems to be the primary basis for associative patterning in the free recall of lexical items, although subjects may be able to recall items by alphabetical association or in terms of progressively increasing size if directed to do so (Gronlund and Shiffrin 1986).

Associative patterns in the recall of persons' names, however, may involve one or more of four general kinds of structures: relational structures, individual characteristics, location, and alphabetic/acoustic similarities of names.

Relational structures

Associative patterns in the recall of persons' names may be based in part on the social relations among persons. Perhaps the most broadly salient relation is interpersonal interaction. People can report quite accurately (in comparison to observed patterns of interaction) on the global social structures of the socially bounded communities in which they are involved (Cairns *et al.* 1985, Freeman *et al.* 1989, Webster 1992). One interpretation of these findings suggests that knowledge of affiliation patterns (i.e. who is friend and who is foe) offers competitive advantage over others and thus humans' (and other species') ability to perceive social structure accurately would be an evolutionary result of this selection process (Freeman *et al.* 1989; see also Cheney *et al.* 1987, Krackhardt 1990, Lachman and Lachman 1979).

There is some evidence that suggests, at least partly, that people remember others in terms of interaction/affiliation patterns. In his study of college students' recall of the names of persons they had met during their lifetime (including relatives, friends, and acquaintances), Riegel (1973) noticed that subjects tended to mention successively persons they first met in the same year. This chronological clustering might reflect recalling persons according to the different social contexts in which subjects had participated (e.g. family, neighborhood, high school, college, etc.). Along these lines, Bond *et al.* (1985), Bond and Brockett (1987), and Fiske (n.d.) found that when people free recall acquaintances the persons remembered are strongly clustered according to social context (e.g. family, dormitory, church, etc.), as well as social role (e.g. teacher) and relationship mode (Fiske, n.d.).

Williams and Hollan (1981) analyzed four high school graduates' recalls of their high school classmates from nine one-hour interview sessions in which subjects were asked to think aloud during recall. The length of time since graduation for these subjects ranged from four to 19 years. They found that subjects used several different strategies in recalling the names of their former classmates. Two of these strategies were remembering persons by group affiliations shared with the subject and general association. Williams and Hollan (1981) defined general association as " ... starting with a known person and searching for people who are directly related in some obvious manner (e.g. a friend, cousin, brother or sister). Occasionally a particular person will suggest a group of people (e.g. a social clique)" (p. 106). They also noticed that "every subject used the strategy of general association at one time or another. Indeed, it appeared that most subjects began their recalls with this strategy" (p. 106). These first general associations produced the densest retrieval (in terms of persons mentioned per unit of time) of classmates' names.

In addition, Freeman *et al.* (1987) observed who attended a weekly departmental colloquium series at a university over a few months. After the last meeting, they asked those who attended the last meeting to name all the people that went to the last colloquium. The proximities of persons in recall for 'in-group' informants (those directly involved in the program sponsoring the series) clearly revealed an in-group/out-group structure, while the recalls of 'out-group' informants' (who were not directly involved with the sponsoring program and attended few colloquia) were not characterized by any such pattern.

Relations other than interaction, friendship, or communication could also relate to associative patterns in the recall of persons' names. For instance, when people recall their kin, genealogical tree structures and kin classes play a role in associative patterning (Alexander 1976, Hammel 1984, Sanday 1969).

Individual characteristics

In every community, some individual characteristics of persons are more important in differentiating members of the community than other characteristics. Examples of this general statement abound in the anthropological and sociological literature. A few studies have

examined how the recall of persons' names relates to the persons' traits. Bahrick *et al.* (1975) studied high school graduates' recall of their high school classmates' names. Subjects were allowed to recall for up to eight minutes. They examined associative patterns for two subsets of subjects, one composed of recent graduates (approximately a month since graduation) and the other consisting of much older graduates (approximately 48 years since graduation), and noticed significant clustering by gender in their recall of classmates. As Bahrick *et al.* (1975) noted, it is not clear whether this clustering by gender reflected association by gender or was a byproduct of association by social interaction patterns, since most social interaction among high school students is with same-gender peers.

The individual traits of persons also were involved in Rubin and Olson's (1980) study of college seniors' recall of their college professors. Subjects' recalls displayed strong clustering according to professors' academic disciplines. Whitten and Leonard (1981) examined college students' recall of their preuniversity teachers. Although subjects were directed to use particular memory search strategies, their 'thinking aloud' protocols indicated that retrieval of names was aided by focusing on a particular academic subject (different teachers teach different subjects in most U.S. junior and senior high schools) for self-cueing recall of teachers' names.

Bond and Brockett (1987) observed weak, but significant, clustering according to persons' personality characteristics within their subjects' social context clusters. Fiske (n.d.) also found weak overall clustering in his subjects' recalls of acquaintances according to such individual characteristics of persons as gender, race, and age. It was not clear, however, whether these clustering patterns were spurious, since both personality and other individual characteristics tend to be unevenly socially distributed in contemporary, socially bounded communities (Arabie 1984, Breiger and Ennis 1979, Iannucci 1992).

Location

In many communities, persons tend to inhabit particular spatial/geographic locations, such as an office in a building, a bunk or room in group living quarters, a home in a neighborhood or village, or a certain part of a classroom, playground, workshop, market, or common meeting area. Since persons in a community are often found in

these locations, schematic cognitive representations of them might in some cases serve as the basis for associative patterns in the recall of persons' names. At least one of Williams and Hollan's (1981) subjects used a locational retrieval strategy in recalling former high school classmates by systematically searching a mental map of where classmates' homes were located. This subject, however, apparently did not begin to utilize this strategy until the second hour-long session of the recall interview. Whitten and Leonard (1981) also observed that subjects sometimes used location-based retrieval strategies in recalling the names of their teachers.

Alphabetic / acoustic similarities of persons' names

While there does not appear to be a major role for alphabetic or acoustic similarity in the undirected free recall of lexical items, there is some evidence to suggest that when persons' names are recalled, the similarity of the names in terms of their alphabetic and acoustic properties can influence associative patterns. This ability might be expected since there are fewer names than there are persons and because records of persons in communities frequently are organized alphabetically (e.g. rosters, telephone books). Rubin and Olson (1980) found that in exception to their subjects' overall clustering by academic discipline, subjects tended to recall adjacently professors who had the same last name, but taught in different fields (there were two pairs of same last name professors). Also, Williams and Hollan (1981) subjects' systematically self-prompted themselves with alphabetic cues for recalling classmates' names. This strategy, though, was used only after several hour-long sessions of the recall interview had been completed. Furthermore, both Fagan (1992) and Fiske (n.d.) noticed that in the recall of high school classmates and acquaintances, respectively, subjects displayed a tendency to recall successively persons whose names were the same.

Frequency patterns

Frequency patterns refer to differences in the likelihood that some persons or types of persons are recalled. Riegel (1973) observed that those persons whom subjects had first met at college and " ... during

the first year of life" (p. 356), such as family, were most frequently mentioned in subjects' recalls of all the persons they had met. These types of persons might be considered those people with whom subjects were most currently and strongly involved. Across all 392 subjects who participated in their study, Bahrick *et al.* (1975) demonstrated that those classmates who were later identified by subjects as close friends or romantic interests were much more likely to be recalled than those considered friends or acquaintances.

Sudman (1988) found that the likelihood of recalling neighbors was positively related to the strength of social tie (acquaintance, friend, close friend) and spatial proximity between respondents and their neighbors. Somewhat paradoxically, however, Sudman (1985) reported that in several different church, social, and work communities, acquaintances were either no less or even more likely to be recalled than friends or close friends.

Freeman *et al.* (1987) showed that 'in-group' and 'out-group' informants differed in which persons they recalled as attending the last colloquium meeting. The recalls of 'in-group' informants were biased towards the long-term attendance pattern, while the recalls of 'out-group' informants were more accurate about who attended that specific event.

Serial order patterns

Systematic tendencies for some persons or types of persons to be recalled earlier or later in recall, or serial order patterns, also may exist in the recall of persons' names. [2] For instance, Fararo (1963) asked people who were involved with community decisions in a city to name the people involved with particular community issues. Although not directly indicated in his results, one possible interpretation of his data suggests that the most frequently named and most prominent figures involved with an issue tended to be mentioned first, followed by the persons in the subject's own political faction, and then persons

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[2] Responses to relation-specific person recall tasks also may exhibit serial order patterns. In response to a question in the General Social Survey regarding persons with whom respondents discuss important matters, persons tended to be mentioned in order of decreasing strength of relationship and frequency of contact (Burt 1986).

seemed to be named at random. In addition, Riegel (1973) found that parents tended to be listed first or early in subjects' recalls of all the persons they had ever met.

Hammel (1984) demonstrated that there were strong serial order patterns in Serbian informants' recall of kin. Subjects varied, however, in the specific dimensions of serial ordering, such as listing male kin earlier than female kin, ascending generations before descending generations, and/or live kin before dead kin (several other serial order patterns also were observed).

Viewed as a whole, the research just reviewed suggests that the memory of persons is organized and that this organization is displayed in free recall. However, most of these studies have not focused on the recall of persons from the same contemporary, socially bounded community by members of that community, and those that did have not given a comprehensive empirical treatment of the three types of response patterning. The main purpose of this study is to provide a detailed analysis of the recall of persons in such a community in order to develop further the understanding of how the memory of persons is organized.

Method

Ethnographic background

The community studied was the graduate student body of the Social Relations program at the University of California, Irvine. As of Winter quarter, 1992, there were 41 students officially enrolled in the program, including 28 females and 13 males. Some age and ethnic diversity existed among the students and a number of students came from foreign countries. Students all had different first and last names from each other, except for two persons who went by variants of the same first name (an example comparable to this case would be the names Joseph and Joe).

The graduate program is an inter-disciplinary program run mainly by anthropology and sociology faculty. All graduate students in the program were pursuing doctoral degrees. Students took approximately

seven to nine years to complete a degree in the program and there was some attrition. The first two years of study in the program were focused on completing program course requirements. Each cohort of students (i.e. students who entered the program in the same year during Fall quarter) took a series of classes together over the first year or two (depending on what point in the program's history) that was explicitly designed to guide students through the initiation and completion of research that resulted in papers roughly equivalent to master's theses. Enrolment in this series was restricted to students in that cohort. Also during the first few years of study in the program, students took required core courses involving students in their first 3 years of study in the program. In addition, students took elective courses that included students at various stages of progress in the program. The numbers of students in each of the nine cohorts (from most junior to most senior) were 4, 9, 6, 5, 7, 5, 3, 1, and 1.

Students, as well as faculty, were quite diverse in terms of their academic interests. This differentiation was reflected by different students working formally and informally with different faculty members, sometimes from different departments. In some cases, there were several students associated with one or a set of faculty members. In some of these cases, the students also worked with each other, for example, as in a large research project. Students who were teaching assistants (most students were at one point or another during their studies) had another institutional context for interaction with other students and faculty.

Students were assigned office space in two large, multi-story buildings in the Social Science complex of the campus. These offices ranged widely in size, housing anywhere from one to over three dozen students, and were distributed across many floors of these buildings. Initial office assignments were arbitrary and made without reference to the student's program, cohort, or any other characteristic. Usually by the third year, students managed to locate office space near or share space with other graduate student friends (not necessarily in the same program, although largely so). Students varied in how much time they spent in their offices, from not at all to several hours each day. Advanced students who were conducting fieldwork or on leaves of absence rarely came to the campus.

Informal social interaction among first-year students tended to be within their own cohort. Faculty emphasized to incoming students that

Table 1
Informants' cohort years, numbers of persons recalled, cohort clustering z-scores, proportions of simulated random paths as large as observed, and ARC scores

Informant	Cohort	No. recalled	Clustering z	Prop. as large	ARC
1	1	23	6.15	< 0.0001	0.67
2	1	17	3.98	0.0140	0.49
3	1	14	7.56	0.0044	0.78
4	2	26	7.40	< 0.0001	0.74
5	2	26	4.36	0.0008	0.43
6	2	26	4.99	0.0003	0.48
7	2	17	7.24	< 0.0001	1.0
8	2	12	3.59	0.1456	0.38
9	2	18	5.61	0.0001	0.72
10	3	28	6.42	< 0.0001	0.59
11	3	16	2.31	0.0839	0.35
12	4	19	1.15	0.2072	0.14
13	4	19	4.10	0.0034	0.50
14	5	20	5.35	0.0001	0.62
15	5	13	3.52	0.0452	0.47
	Mean	19.6	4.92		0.56
	Median			0.0008	
	Cumulative Z [a]		19.04		
Retest					
9	2	16	7.12	< 0.0001	1.0
13	4	24	8.22	< 0.0001	0.85

[a] From Stouffer's method of aggregation (Mosteller and Bush 1954).

their primary source of social support in the program would be the students in their cohort. As students advanced further in the program, informal social ties and friendships tended to become more based on shared academic interests, experiences (e.g. as with office mates, fellow teaching assistants, etc.), and other factors.

Informants

Informants were 15 graduate students from the program, including 12 females and three males, and students from each of the five most recent cohorts (from first to fifth year students) (see Table 1). Aside from the absence of very senior students, this sample appeared to be quite representative in terms of students' demographic characteristics, academic interests, and office locations.

Procedure

Informants were interviewed individually during Spring quarter, 1992. Two informants who were available were reinterviewed for the same recall task two to three weeks after the first interview in order to assess the reliability of recall patterns. The interview was administered via microcomputer with a standard keyboard layout. In the interview, the first screen presented to a informant consisted of an introduction to the experiment and instructions for how to respond on the keyboard. I then reviewed these instructions with the informant orally. The next screen showed the question, "Who are all the graduate students in the Social Relations program? (You can use their first and/or last names and you do not need to put your name as a response) ." [3] No instructions were given regarding the order in which informants were to list names. Several lines below the question, the cursor would be blinking and informants could type names which would be displayed on the screen. After typing a name, informants were to hit the enter key, which would cause the name to disappear from the screen and the blinking cursor to return to its original position below the question. Then informants could type in additional names, each time hitting the Enter key after typing a person's name. Informants were given up to ten minutes to recall as many persons as they could, but all informants finished within 107 to 382 seconds (i.e. less than seven minutes), saying that they could remember no more.

Since the recall of persons was the only task informants performed, their patterns in recall are not confounded by any short-term memory processes introduced by preceding tasks and thus their response patterns were thought to reflect long-term memory structures and processes.

Two types of recall data were extracted from these responses. First, the recall order of all the names mentioned by a informant was obtained. Second, the time (precise to a hundredth of a second) at the strike of the first letter, last letter, and Enter key for each name was recorded for every informant's recall. Cohort information for each of

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[3] In pre-testing these elicitation procedures with people from other contemporary, socially bounded communities, I found that they usually would stop halfway through their recall to ask if they should mention their own name. Since this issue disrupted the process of their recall, I believed it was best to instruct informants not to recall their own name.

the 41 students in the program was obtained from the School of Social Sciences' graduate advisor.

Results

On average, informants recalled approximately half of the students in the program (see Table 1) and all of the 41 students in the program were recalled at least once. Three informants mentioned themselves and two informants repeated a person in recall. Three informants recalled two persons not in the program, one informant recalled four persons not in the program, and one informant mentioned a name that was not recognizable. Of these intrusions, three persons had once been in the Social Relations program but had since transferred to different graduate programs, one had taken several classes in the Social Relations program even though enrolled in another program, and another was not connected to the program at all. Self-mentions, repetitions, and intrusions are not included in the total numbers of persons recalled in Table 1.

Association

Nearly every informant's recall exhibited clear associative structure. Initial inspection of informants' recall orders suggested that informants were clustering their recall of fellow students by cohort. This impression was tested with a clustering measure developed by Hubert and Levin (1976) based on quadratic assignment. The cohort structure was represented in a matrix where the only distinction made among the students was whether a pair of students were in the same cohort or not. This was coded as a 41 × 41, symmetric, binary cohort person by person matrix, in which a cell had a '1' if a pair of persons was in the same cohort, and '0' otherwise. An informant's recall order can be considered as a path through a 'complete' graph representation of this cohort structure matrix, where each link (or edge) in the graph takes a value (1 or 0) corresponding to the cell in the matrix for that pair of persons. The number of links in the path is equal to number of persons recalled minus one and the length of an informant's path is defined to be the sum of the link values for the pairs of adjacently

recalled persons. Self-mentions and intrusions were not included in informants' recall paths. When a informant repeated a name, the observed path length for clustering analysis was computed to be the total path length (including the repetition) minus the mean link value for the total path.

Clustering is specifically indexed for each informant by a z-score which is the difference between the observed path length and the expected by chance (mean) path length for all possible paths among those persons recalled (i.e. for all permutations of the recall order), divided by the standard deviation of path lengths for all possible paths among those persons. In this case, paths longer than expected by chance indicate clustering. Clustering z-scores were computed separately for each informant for just the set of persons recalled by that informant. The distribution of all possible paths among the set of persons recalled by a informant was not always approximately normal. Therefore, more sensitive, non-parametric Monte Carlo probability values for the significance of clustering were estimated by simulating 10 000 random paths, for each informant, for the set of persons recalled and noting the proportion of path lengths that were at least as large as the informant's observed path length. To give a perspective on the magnitude of clustering, Adjusted Ratio of Clustering (ARC) scores (Roenker *et al.* 1971) were computed. This measure equals the (observed path length − expected path length)/(maximum possible path length − expected path length), ranges between −1 and 1, and takes a value of 0 for expected by chance clustering and a value of 1 for maximum clustering.

The clustering z-scores, proportions of random paths that were as large, and ARC scores for each informant appear in Table 1. Informants displayed strong and highly significant clustering according to the binary cohort structure. Informant 7's recall, for instance, was maximally clustered by cohort. In other words, informants were very likely to recall persons in the same cohort consecutively. Interestingly, first year students, who had only been in the program for about seven months, and other junior students did not differ noticeably from senior students in the degree of clustering or number of persons recalled, as shown by non-significant results from various statistical tests. Also, the two persons whose first names were variants of the same name were in different cohorts three years apart and were never recalled adjacently.

Other evidence indicates that the cohort structure describes some of the associative patterning in informants' recalls. Two informants spontaneously remarked during the recall interview that they were remembering persons by cohort. Another informant counted on her fingers during the recall interview as if mentally enumerating persons in a cohort. In addition, the two informants who did the recall interview twice showed marked increases in clustering by cohort at retest (see Table 1).

Furthermore, the inter-response times (IRTs) between adjacently recalled persons who were in the same cohort (within-cohort IRTs) were shorter than the IRTs between adjacently recalled persons who were in different cohorts (between-cohort IRTs). Excluding those pairs of adjacently recalled persons which involved self-mentions and persons not in the program, the amount of time elapsed between the strike of the last letter of one person's name and the strike of the first letter of the next person's name was computed for every pair of adjacently recalled persons in each informant's recall. The within-cohort IRTs were shorter on average than the between-cohort IRTs for 13 of the 15 informants, and these differences, when aggregated over informants, were significant (cumulative Z for individual informants' t scores was -3.66, $p < 0.001$, mean eta $= 0.23$) (Rosenthal 1991, Winer 1971). Very similar results were obtained when Mann-Whitney tests were calculated, when the IRTs were based on the elapsed time between the strike of the Enter key and the first letter of the next person's name, and when log transformed IRTs were used (to make the positively skewed within- and between-cohort IRT distributions more normally shaped).

On the basis of all of these results, it seems legitimate to conclude that the cohort structure provides a good description of each informant's associative patterning. Since this was the case, it was fair to aggregate data regarding associative patterns across informants. Aggregation here allows the visual representation of associative patterns. To this end, an aggregated data matrix was constructed from informants' recall orders after self-mentions, intrusions, and repetitions had been removed. A 41×41 symmetric person by person matrix was created for each informant where a cell representing a pair of persons held a '1' if these persons were adjacent in recall, and '0' otherwise. Diagonal values were '1' if that person was recalled by that informant, and all cells representing a pair of persons that did not both occur in
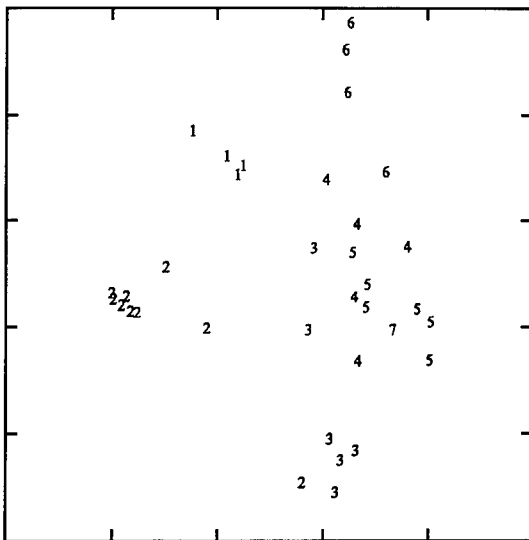
Fig. 1. Two-dimensional correspondence analysis representation of adjacencies in recall orders. Numbers represent cohort years of persons.

that informant's recall contained zeros. These individual matrices were added to arrive at a single aggregated adjacency matrix. The rows and columns referring to the six persons recalled only once were deleted from this aggregated matrix.

This 35×35 adjacency matrix was scaled with correspondence analysis (Gifi 1990, Weller and Romney 1990). A two-dimensional representation of the adjacency matrix, accounting for 22.9% of the variance, appears in Fig. 1. The numbers plotted denote the cohort years of persons. In the figure, the closer two persons are, the more frequently they were recalled consecutively. The cohort structure is clearly exhibited for the first few cohorts and higher dimensions did not provide more differentiation among the senior cohorts. The lack of strong clustering of persons in more advanced cohorts in the figure may be due the underrepresentation of informants from those cohorts, since more junior students may not know exactly which cohort those persons belong to, even though these informants may know that these persons are senior students and cluster them accordingly in recall.

In fact, informants were less likely to cluster by cohort persons from cohorts which were chronologically distant from themselves, as op-

posed to persons in their own or chronologically close cohorts. For each informant, the number of observed within-cohort adjacencies and the maximum possible number of within-cohort adjacencies were computed for each cohort in which two or more persons were recalled. Then, the number of observed within-cohort adjacencies was divided by the maximum possible number of within-cohort adjacencies for cohorts of zero (informant' s own cohort), one, two, and three or greater years distance from the informant's cohort. These proportions, averaged across informants, were 0.80, 0.57, 0.36, and 0.43, for cohort distances of zero, one, two, and three or greater years, respectively, and the differences were significant ($F(3, 48) = 5.46$, $p < 0.01$).

Frequency

Inspection of informants' recall orders suggested that the cohort structure also influenced frequency patterns. It appeared that informants were more likely to recall persons in their own and chronologically close cohorts than persons in chronologically distant cohorts. To test this hypothesis, Goodman and Kruskal's (1954) gamma was computed for each informant between the proportion of persons recalled from each of the nine cohorts (self-counted as a response in the informant's own cohort) and the absolute value of ordinal cohort distance (i.e. years) from the informant for each of these cohorts. These results appear in Table 2. Informants were very likely to recall all or nearly all persons in their own cohorts, with the proportion of persons recalled in other cohorts tending to decrease as the cohort distance from the informant increased. Informants also did not recall persons from every cohort, but tended to mention at least one person from about six of the nine cohorts (see Table 2). Two cohorts (eighth and ninth year students), however, only had one person each.

The tendency to recall persons close to one's own cohort is also shown by another piece of evidence. An ordinal distance cohort structure matrix was created which reflects the distance, in terms of years, between persons according to the year of their cohorts. This was coded as a 41 × 41, symmetric, ordinal cohort distance person by person matrix, where a cell represents the absolute value of the difference in years between a pair of persons' cohorts. The persons recalled (unordered) by an informant tended to be more concentrated (not dispersed) in the ordinal distance cohort structure than would be

Table 2
Informants' gamma coefficients for frequency (F) and serial order (SO) patterns according to cohort distance, numbers of cohorts in which at least one person was recalled, and dispersion z-scores according to ordinal distance cohort structure

Informant	Gamma – F	Gamma – SO	No. cohorts	Dispersion z
1	−0.70	0.78	7	−2.06
2	−0.73	0.19	5	−2.02
3	−0.81	0.67	6	−2.42
4	−0.88	0.73	7	−2.91
5	−0.81	0.54	6	−4.02
6	−0.46	0.68	7	−1.24
7	−0.93	0.55	5	−3.91
8	−0.58	0.32	4	−2.25
9	−0.72	0.72	5	−3.04
10	−0.76	0.22	7	−2.20
11	−0.83	0.54	4	−4.03
12	−0.77	0.08	5	−3.16
13	−0.52	0.10	6	−0.83
14	−0.36	0.35	7	−0.44
15	−0.85	0.40	5	−2.30
Mean	−0.71	0.46	5.7	−2.46
Retest				
9	−0.69	0.84	6	−2.14
13	−0.87	0.24	7	−2.50

expected by chance, as measured by z-scores from normal approximations of Hubert and Schultz's (1976) quadratic assignment procedure (see Table 2).

The similarities between the unordered recalls of the first and second interviews for Informants 9 and 13 reinforce these findings on frequency patterns. Over both interviews, Informant 9 mentioned 19 unique persons, 15 of whom were common to both interviews (Jaccard coefficient = 15/19 = 0.79). Informant 13 mentioned 26 unique persons over the two interviews, with 17 of these in common between the two interviews (Jaccard coefficient = 0.65). Those persons who were recalled in one interview but not the other were never in the informant's own cohort. Also, the number of persons recalled was approximately the same for both interviews. Informant 9 recalled 18 and 16 persons in the first and second interviews, respectively, and Informant 13 recalled 19 and 24 persons in the first and second interviews, respectively.

Serial order

Since both associative and frequency patterns were based on the cohort structure, it seemed likely that serial order patterns, if any existed, might also be based on the cohort structure. Examination of informants' recall orders suggested that informants tended to recall persons in their own cohort first, then persons in the cohort immediately preceding or following (in chronological terms) their own, and persons in cohorts distant from their own (regardless of chronological direction from the informant) later in recall. These impressions were tested by measuring the degree of association between the output serial position and absolute value of ordinal cohort distance from the informant for each person recalled. Goodman and Kruskal's (1954) gamma was computed between these variables for each informant and the results are presented in Table 2. All informants' coefficients were in the expected direction and indicate a moderate degree of association. The effect of cohort distance from the informant on serial position also was examined at retest for the two informants who performed the recall task twice. The tendency to remember persons in one's own cohort first and persons from more distant cohorts later in recall increased at retest for these two informants (see Table 2). To test for the correspondence in the serial orders of persons mentioned in both the first and second interviews, Goodman and Kruskal's (1954) gamma, which in this case is also Kendall's (1938) tau, was calculated between the relative ranks for those persons in common to both of an informant's recalls. These coefficients were 0.58 for informant 9 and 0.02 for informant 13. The lack of concordance between the serial positions of persons in the first and second interviews for Informant 13 demonstrates the possible difference in influence of cohort distance on serial order between the two interviews for this informant (from weak in the first to moderate in the second).

Discussion

Informants' recall of persons' names in this contemporary, socially bounded community was highly structured in terms of associative, frequency, and serial order patterns. Individual informants shared a common structure in the recall of fellow students. For each type of

pattern, the cohort structure of the students played a central role in the organization of recall. Informants recalled persons by cohort, typically beginning with their own, and then moving to cohorts that were progressively more distant (in terms of years) from themselves. Persons in cohorts that were distant from the informant were less likely to be recalled than persons in cohorts close to the informant.

In several ways, these results are similar to findings in research on the recall of lexical items. The strong associative patterning in informants' recall orders was also exhibited in the temporal characteristics of their recalls. The IRTs between adjacently named persons were shorter for within-cohort pairs of persons than between-cohort pairs of persons, which is congruent with results on IRTs in the recall of mixed category lists of words (Hoermann and Osterkamp 1965, Kellas *et al.* 1973, Mandler 1970, Patterson *et al.* 1971, Pollio *et al.* 1969), words from homogeneous semantic domains (Gruenewald and Lockhead 1980), and students' recalls of their professors by academic discipline (Rubin and Olson 1980).

Over the course of their graduate studies, informants tended to have interacted most with those persons in their own cohort, next most with persons in cohorts chronologically close to their own, and least with persons in distant cohorts. The frequency pattern observed here mirrors these interaction patterns, which resembles findings in research on the recall of lexical items. Mervis *et al.* (1976) demonstrated that when informants are asked to free list lexical items in a semantic domain, those words that are more frequently recalled are also items that are more typical, in the sense that they are judged as better examples of that domain than words less frequently recalled. Similarly, those items that are more frequently recalled are also more quickly judged as members of a given domain than less frequently recalled items (Loftus 1973, Wilkins 1971). In previous studies on the recall of persons' names, those persons with whom informants had strongest ties/intense interaction (Bahrick *et al.* 1975, Riegel 1973, Sudman 1988) or who were most visible (Freeman *et al.* 1987) were most likely to be recalled (Sudman 1985, is an exception, however). These findings, together with the results in this paper, might possibly indicate a frequency–typicality relationship in the recall of persons' names, where typicality represents the degree to which persons are most closely identified, *from the perspective of an individual informant*, with the community in question.

The fact that the cohort structure underlay both frequency and serial order patterns was in accordance with research on the recall of lexical items. Several investigators have found that in free listing tasks within a semantic domain that there is a fairly close correspondence between frequency of mention and output serial position in recall, with frequently listed words tending to be mentioned early in recall (Battig and Montague 1969, Bousfield and Barclay 1950, Romney and D'Andrade 1964). Hence, serial order and frequency patterns in free recall might just be different ways of measuring the same basic concept of a lexical item's or person's cognitive salience. At least in the present study, though, the salience of a person varied across informants as a function of the informant's position in the cohort structure.

Not only were persons in cohorts distant from a informant less likely to be recalled, those persons from distant cohorts who were recalled by a informant also were less likely to be clustered by cohort. These results suggest that informants' knowledge of persons and their cohort memberships decreased with increasing cohort distance. Similarly, Freeman and Webster (n.d.) showed that in two contemporary, socially bounded communities (one recreational and the other residential), individuals have more detailed and structured knowledge of the patterns of social ties for persons who are socially close to themselves than for persons who are socially distant. They found that people perceived socially distant subgroups as relatively homogeneous and undifferentiated in terms of affiliation patterns, just as in this study persons in distant cohorts were lumped together in recall as relatively senior or junior students, sometimes blurring differences in cohort membership.

As a concept, the cohort in this program had components of social interaction, individual traits, and formal organizational structure. During the early stages of study in the program, the cohort was a key focus of social interaction both inside and outside of classes, and continued to be a factor in shaping social interaction patterns among students in later stages of the program. Cohort membership was also a general indicator to students and others in the program of a student's progress in the program, and thus her/his academic status, work schedule, and activities. Moreover, the cohort structure was the program's official way of organizing and classifying students. With the available data, it is not possible to determine which of these three

aspects of the cohort structure is most critical or operative in organizing persons in memory. In any case, it is apparent that this study does not support Bond and Brockett's (1987) notion that persons within a social context are organized in memory according to personality characteristics.

Recent research suggests that names of persons are neuropsychologically distinct from lexical labels. There have been reports of aphasic patients whose ability to retrieve acquaintances, relatives, and/or famous persons' names (in contrast to lexical items from semantic domains and generic first names such as Mary and Bill) was selectively preserved or impaired (McKenna and Warrington 1980, Semenza and Zettin 1988, 1989, Warrington and McCarthy 1987). In addition, names of persons who are/were personally known to informants appear to be distinguishable from episodic autobiographical information and non-autobiographical semantic information, as shown by patterns of total output frequencies in free recall tasks (Dritschel *et al.* 1992). Such findings provide additional impetus for understanding how the memory of persons is organized. Further research on the recall of persons' names in contemporary, socially bounded communities, varying in composition, function, and structure and including developmental and cross-cultural studies, will help clarify what is unique about the recall of persons in this community and determine what general properties there are in the recall of persons.

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ARTICLES

A Note on the Relationship Between Centrality and Cultural Knowledge in a Professional Network

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Abstract

This paper examines the relationship between centrality and cultural knowledge in a network of corporate contributions officers, based on data collected by Galaskiewicz (1985b). The results indicate a moderate association between officers' centrality and knowledge of local nonprofit organizations, with membership in professional associations and gender also playing independent roles in the distribution of knowledge.

It has been widely recognized in the social sciences that cultural knowledge in any community is unevenly shared by its members. It also has been frequently asserted that the pattern of social ties in a community underlies intracultural variation. Despite the long held interest in the social distribution of knowledge, a coherent and sustained program of systematic research on the subject has only recently come together.

Work by a number of researchers (e.g., Campbell, 1955; Hammer, Polgar, and Salzinger, 1969; Romney and Faust, 1982; Romney and Weller, 1984; Boster, Johnson, and Weller, 1987; Freeman, 1987; Freeman, Romney, and Freeman, 1987; Krackhardt and Kilduff, 1990; and Boster and Johnson, 1992) has shown that individuals' knowledge about a community's social structure and the characteristics of others is related to their positions in the community's social network.

This body of research has led to the general conclusions that the more people interact with others in the community, the more they agree and know about others in the community, and that the more integrated into a community a person is, the more s/he knows about the community's social structure. However, the available evidence does not indicate what aspect of greater interaction with others it is that increases knowledge of a social structure and others' characteristics. Being more central in a group may allow one to receive more second-hand information about the community's social structure and others' attributes from communicating with one's contacts, which would increase one's social knowledge of the community and its members. It is equally possible, as Linton Freeman pointed out to the author in personal communication, that people in more central positions can better observe, first hand, the community's social structure and others' characteristics, and that communication with others may not be the main source of acquiring this knowledge.

A better context for examining the role of social ties in the transfer of cultural knowledge is in areas of knowledge that do not focus on the social structure or attributes of persons in a community and where verbal communication clearly is at least one necessary part of the process of acquiring knowledge.

Boster (1986) was the first to demonstrate in an explicit network sense that cultural knowledge of non-social content also can be distributed according to the patterning of social ties. He showed that Aguaruna women who were more involved in extra-kin manioc exchange networks had greater knowledge (measured by cultural competence, an estimate of informant knowledge derived from analyzing the pattern of agreement among informants · see Romney, Weller, and Batchelder, 1986) about manioc identification than women whose exchange was limited their respective kin groups. Deviations from the consensus, however, were patterned along kinship lines, as women were much more likely to exchange manioc varieties with kin. While shared experience with the ar manioc plants was a component in learning the names for the different varieties, the names definitely coul have been acquired without verbal communication among the women regarding the plants' labels.

Similarly, Brewer (in press) observed that graffiti writers who were centrally positioned (centrality was informally measured) in local graffiti writer networks and who had more ties to writers in other communities knew more (i.e. had greater cultural competence) about the effectiveness of various strategies to control illegal graffiti than more peripheral writers to whom the central writers had first-order links.

This paper adds to the previous research by examining the relationship between centrality in a social network and cultural knowledge using data collected by Galaskiewicz (1985b). First, Galaskiewicz' research on the social distribution of knowledge is reviewed. Next, the procedures of reanalysis are described, and then the results are presented. The final section discusses these findings.

Galaskiewicz' Research on the Social Distribution of Knowledge

The primary focus of Galaskiewicz' research on the social distribution of knowledge has been to investigate how corporate contributions officers decide to which charitable nonprofit organizations (NPOs) they should donate (Galaskiewicz, 1985b; Galaskiewicz and Burt, 1991). Corporate giving officers are responsible for overseeing charitable donations to NPOs in publicly held business corporations (for a more detailed description of the study population, see Galaskiewicz, 1985a, 1985b). Underlying the process of deciding which NPOs to support financially, according to Galaskiewicz and other organizational researchers, is a sense of uncertainty about community needs and the nature and quality of the services provided by prospective donees, since corporations themselves are not the beneficiaries or consumers of the services the NPOs provide. This uncertainty has been hypothesized to stimulate officers to seek more information about NPOs from independent sources, especially peer contributions officers in other corporations, in order to make their contributions decisions effectively. Even when officers do not actively seek out peers for information about particular NPOs, it was thought that officers still acquire a large amount, if not most, of their knowledge about NPOs through communication with other contributions officers.

The data

The main data set analyzed by Galaskiewicz (1985b) and Galaskiewicz and Burt (1991) includes responses from 61 corporate giving officers in the Minneapolis/St. Paul area. All of the officers were employed by firms with more than 200 employees. The data relevant to the present paper are of three basic types: sociometric data, characteristics of the officers and their firms, and officers' evaluations of local NPOs. The sociometric data consist of a 61 X 61 binary nonsymmetric matrix A_{ij} in which a cell has a "1" if the contributions officer (the person most responsible for charitable activities) in firm i reported person-ally knowing someone ". . . involved in corporate contributions, i.e. on a first-name basis, would feel comfortable calling for lunch or drinks after work, etc.," (Galaskiewicz, 1985b: 647) in firm j, or a "0" otherwise. Thus, the data is not exactly of the person by person type. Galaskiewicz and Burt (1991) noted that this network exhibits an overall core-periphery structure.

The data on the officers and firms' characteristics include eleven variables. Seven variables concerning the officers' characteristics are dichotomous: gender, prior work experience in human services, status in firm (whether their job was as a semi-professional or professional contributions officer), whether an officer consults with a peer in another corporation or foundation to get more information on prospective donees (NPOs), and membership in each of three local professional associations for contributions staff (BARC, MCF, WFCP). Data was also collected on officers' educational history (high school, undergraduate, graduate) and birthplace (Minneapolis/St. Paul, North Central U.S., elsewhere). Although not analyzed by Galaskiewicz (1985b) and Galaskiewicz and Burt (1991), the present paper also includes the average assets and revenues for officers' firms between 1979 and 1981 as measures of firms' financial size.

To tap officers' knowledge of NPOs, respondents were presented with a list of 326 NPOs (representing a 20% stratified systematic sample of nonprofit public charities [excluding private foundations and churches] in the Minneapolis/St. Paul metropolitan area) and asked which ones they recognized. In addition, for those NPOs recognized, respondents indicated which were providing essential services and had made outstanding achievements in their respective fields.

Summary of Galaskiewicz (1985b) and Galaskiewicz and Burt's (1991) findings

Galaskiewicz (1985b) found that the more proximate two officers were in the officer network, the more they agreed with each other in their recognition and evaluation of the NPOs. By taking the intersection of A (officer in firm i knew someone in firm j, and vice versa), calculating the path distances between each pair of officers, and

then submitting this path distance matrix to multidimensional scaling, Galaskiewicz obtained a measure of inter-officer network proximity from the resulting interpoint distances in a two-dimensional scaling. He measured agreement between pairs of officers in their recognition and evaluation of NPOs with Jaccard coefficients. This index of similarity can be expressed simply as the number of shared elements (i.e. intersection) in two sets (e.g., NPOs two officers both recognized) divided by the number of items in the union of the two sets (e.g. the total number of unique NPOs recognized by a pair of officers). Galaskiewicz calculated Jaccard coefficients for each pair of officers on each level of evaluation (recognition, essential services, and outstanding achievements). The zero-order Pearsonian correlations between officers' interpoint distances and Jaccard coefficients were .10, .05, and .09 (all $p < .001$ since the dyad was the unit of analysis) for recognition, essential services, and outstanding achievements, respectively.

Galaskiewicz and Burt (1991) extended these initial findings. In their analysis, officers' responses regarding the NPOs were coded on a three category response variable (1 = did not recognize, 2 = recognized, 3 = recognized and outstanding achievements). Galaskiewicz and Burt (1991) employed network autocorrelation techniques and demonstrated, for a subset of ten NPOs which had been given the highest and most variable evaluations, that agreement in recognition and evaluation of these NPOs was associated with structural equivalence ($r = .54$). This correlation was greater than the one observed between agreement and "cohesion," which was measured by comparing officer i's evaluations with all officers who had direct ties to firm i, $r = .29$.

They also noticed that more prominent officers (officers' prominence scores were strongly associated with eigenvector measures of prestige and centrality) tended to recognize more of these ten NPOs than less prominent officers.

Purpose of this paper

The reanalysis reported in this paper builds upon the work of Galaskiewicz (1985b) and Galaskiewicz and Burt (1991). The present paper differs in two principal ways by focusing on officers' *centrality* in the network (rather than structural equivalence, dyadic/"cohesive" ties, or network path distance proximity) and their *knowledge* of the NPOs (instead of only agreement in their evaluations). The primary hypothesis tested is whether the information in the sociometric data can predict which officers are the most knowledgeable (regarding the NPOs). Specifically, the hypothesis postulates that officers who are more central in the network should possess greater knowledge of the NPOs. If cultural knowledge is transmitted through social ties involving communication, then positions within in a network where information flow is most focused should also be the loci where cultural knowledge, as accumulated and shared information, is greatest.

Procedure

Four officers' firms did not receive any sociometric choices nor did these officers report knowing contributions personnel at any of the other firms. These four officers were omitted from further analysis because the aim was to observe the distribution of knowledge across a network, and not among unconnected isolates. The 57 X 57 binary nonsymmetric matrix was then converted into a three valued matrix according to the following rule: cell a_{ij} has a "0" if neither i nor j chose one another, a "1" if either i chose j or j chose i, but not both (i.e. an unreciprocated tie), or a "2" if i and j both chose each other (i.e. a reciprocated tie). The rationale for doing this is twofold. First, 63% of the choices in the 57 X 57 binary nonsymmetric matrix were not reciprocated.

The average officer had only 24% of his/her choices reciprocated, with the percentage of reciprocated choices ranging from 0% to 76%. By transforming into a valued matrix, it was not necessary to ignore nearly two-thirds of the sociometric data. Second, Granovetter (1973) points out that in a free-choice sociometric interview, mutual choices can be indicators of strong ties, while unreciprocated choices would tend to reflect weaker ties. Galaskiewicz (1985b) noticed that officers i and j might not know each other personally even when a reciprocated tie exists because they might know other contributions staff who work with the officers interviewed, but not actually each other. A similar scenario could relate to the unreciprocated choices in the data. For instance, officer i could know someone involved in contributions at firm j, but not the officer interviewed, while at the same time officer j was not aware of a colleague's tie with the officer interviewed in firm i. Even if the responding officers did not know each other personally, or were involved in an unreciprocated choice situation as described above, it is assumed in this analysis that there was at least some information flow among contributions staff within the same firm.

Three different measures of centrality were used in this analysis because there was no theoretical indication about which of the specific processes modeled by different centrality measures might best represent the process generally stated in the hypothesis. The first, Freeman, Borgatti, and White's (1991) flow betweenness algorithm, is

based on the role each point plays in terms of network flow for all independent paths between all pairs of points in a valued or binary graph. Stephenson and Zelen's (1989) information centrality index was also used. This measure is based on the inverse of path distances between all pairs of points for all paths, with appropriate adjustments made for overlapping paths and valued ties. Thus, points that are closer (in a path distance sense) to other points and have more connections (greater degree) of higher values with other points will have higher information centrality scores. The third centrality measure employed was Bonacich's (1971) eigenvector measure, which is the eigenvector of the largest eigenvalue of a binary or valued adjacency matrix (i.e. individuals' centrality scores are the loadings on the first factor from a factor analysis of the adjacency matrix).

In this analysis, an officer's cultural knowledge of local NPOs is loosely measured by the total number of NPOs they recognized. This index is similar to the total amount of lexical items in a semantic domain an informant can mention in an open-ended free listing task (e.g. "What are all the kinds of fabrics?"). Brewer, Romney, and Batchelder (in preparation) have discovered that in semantic domains such as birds, countries, diseases, fabrics, and flowers, free listing capacity was correlated approximately .41 with cultural competence (an estimate of an informant's knowledge level based on the pattern of agreement among informants – see Romney, Weller, and Batchelder, 1986) in triads judged similarity tasks. This correlation is probably depressed because in all domains studied there was relatively little genuine variation in knowledge (cf. Weller, 1987). Although admittedly crude, this recognition measure is the only way to gauge knowledge in this data set, since Jaccard coefficients, correlations between respondents on the three category response variable used by Galaskiewicz and Burt (1991), or any other measure of agreement, cannot be meaningfully submitted to any procedure that estimates individuals' knowledge level based on patterns of agreement (cf. Weller, 1984; Boster, 1985; Romney, Weller, and Batchelder, 1986; Romney, Batchelder, and Weller, 1987). This is not to deny that more specific and greater amounts of knowledge are required for evaluation of NPOs beyond recognition; it is just that this information cannot be effectively used in estimating officers' knowledge in this particular case. However, the recognition measure used here does take advantage of officers' responses for all 326 NPOs, in contrast to Galaskiewicz and Burt's (1991) use of the subset of only ten NPOs.

Results

The summary statistics for each of the centrality measures appear in Table 1. There was a substantial amount of variation in the number of NPOs the officers recognized, with a mean of 53.46 and standard deviation of 21.97 (minimum = 5, maximum = 115). The Pearsonian correlations among the centrality measures and recognition are shown in Table 2. Scatterplots of these variables did not exhibit any obvious nonlinear patterns. The total number of NPOs recognized was correlated approximately .5 with the various centrality measures. Therefore, the hypothesis that more central officers should "know" more about the NPOs received moderate support. In addition, all of the centrality measures were highly intercorrelated, though the information index was somewhat different from the flow betweenness and eigenvector measures, which were more strongly correlated with each other.

Table 1. Summary Statistics for Centrality Measures

Measure	Mean	S.D.	Centralization Score
Flow Betweenness	.02	.02	.05
Infomation[a]	.02	.01	< .01
Eigenvector	.02	.09	–

[a] The information centrality scores were computed by dividing each person's information by the sum of all person s' information. The centralization score represents the variance of these centrality scores, as suggested by Wasserman and Faust (1992).

Table 2. Correlations Between Centrality and Recognition.

Measure	Recognition	Flow Betweenness	Information
Flow Betweenness	.45		
Information	.50	.77	
Eigenvector	.57	.92	.84

all correlations p < .001

The results on the relationship between centrality and recognition were not due to the fact that unreciprocated ties were included in the computation of centrality. For the 39 X 39 binary symmetric matrix based on the intersection of sociometric choices, correlations between recognition and centrality were of the same strength and direction for various measures of centrality: .43 (p < .01) for degree centrality, .42 (p < .01) for closeness centrality, .25 (p < .15) for betweenness centrality, and .34 (p < .05) for flow betweenness centrality (Freeman, 1979). Comparable results were obtained when the 57 X 57 binary symmetric matrix based on the union was analyzed. Furthermore, the correlation between recognition and centrality for those ten officers in the valued 57 X 57 matrix who had no outdegrees (i.e. made no sociometric choices) was .56 (p < .1), .65 (p < .05), and .67 (p < .05) for the flow betweenness, information, and eigenvector measures, respectively. For the other 40 officers who had at least one outdegree (sociometric choice), these correlation were .40 (p < .01), .43 (p < .01), and .56 (p < .001) for the same centrality measures. Therefore, even though ten officers made no sociometric choices to other firms, the indegrees to the these officers' firms still carried important structural information that related to the distribution of knowledge.

How good is a correlation of approximately .5 in this case? By comparing the bivariate relationships between other independent variables and recognition, the relative strength of centrality as a predictor of knowledge can be better understood. Consultation with peers regarding prospective donees, birthplace, and education all were unrelated to the number of NPOs recognized in t-tests or analyses of variance, and both assets and revenues of officers' firms were nonsignificantly correlated with recognition. However, several other variables were moderately associated with recognition. Officers who recognized more NPOs tended to be members in one or more of the local professional associations (t = -5.50, df = 43, p.001, eta = .61), female (t = -3.44, df = 13, p = .004, eta = .42), have prior work experience in human services (t = -2.39, df = 14, p = .03, eta = .33), and have professional job status (t = -3.485, df = 50, p = .001, eta = .43)(separate variances used in calculations; nonparametric results virtually identical to those reported here). Thus, centrality was just one of several variables that moderately predicted recognition.

An attempt was made to see which variables provided additional independent information in predicting recognition after controlling for centrality, since some of these variables were also associated with centrality. The partial correlations (controlling for each centrality measure in turn) between recognition and firms' assets and revenues were nonsignificant. For the categorical officers' characteristics variables, t-tests or analyses of variance were carried out on the residuals of the simple regression between recognition and centrality for each centrality measure. Members of local professional associations (p = .004, .014, and .119 for flow betweenness, information, and eigenvector measures, respectively) and women officers (p < .001 for all centrality measures) recognized significantly more NPOs than would be expected given their centralities. However, once centrality was controlled for, no differences in recognition remained between subgroups on any of the other variables (all p > .05 for each centrality measure, except for human service experience X information centrality - recognition residuals, Mann-Whitney p = .05). Interestingly, gender was not significantly associated with any other variable in the data set.

Despite the earlier listing of association membership as a characteristic of officers, it seems better to view it as a structural variable. Association membership and centrality were moderately related (eta = .58, .65, and .75 for flow betweenness, information, and eigenvector measures, respectively; all t-tests and Mann-Whitney tests p < .001). More importantly, membership in one association most likely offered an officer access to some information of local NPOs held by other associations and also to more social ties with other officers because the memberships of the three associations overlapped substantially. This overlap can be seen in the association X association membership matrix in Table 3. Because information seemed to flow relatively easily within an association (". . .they [the associations] provided program activities which allowed these staff people to get to know one another and community problems better (e.g. breakfasts, conferences, seminars, etc.") (Galaskiewicz, 1985b: 647)), it seems plausible that membership in one association allowed an officer access to a substantial amount of knowledge about the NPOs held by members in other associations. This interpretation is supported by the fact that officers who belonged to more than one association did not recognize significantly more NPOs than officers who belonged to only one association. The mean numbers of NPOs recognized for officers belonging to zero, one, two, and three organizations were 42.75, 68.88, 71.71, and 57 (n = 1 officer), respectively. Officers belonging to two or three associations did not recognize significantly more NPOs (t = -.12, df = 16, p = .90) or have greater centrality (t = -.39, df = 13, p = .70) than officers belonging to only one association. Thus, the memberships of the three associations did not compose separate clusters of ties among officers (as did kin groupings among Boster's (1986) manioc cultivators), rather they consolidated the core of the officer network, which presumably homogenized the knowledge base (in terms of recognizing the NPOs) for these more central officers who were members of a professional association. From these data it was impossible to determine whether officers' greater centrality predisposed them to association membership or membership in an association allowed officers to develop additional ties which

produced their greater centrality, or some combination of these two processes. The main point here is that centrality and association membership should be viewed as complementary structural variables, and not as entirely different forces in the distribution of knowledge among contributions officers.

Table 3. Overlapping Association Memberships

	BARC	MCF	WFCP
BARC	18		
MCF	6	12	
WFCP	1	3	3

N = 24 contributions officers who were in one or more associations.

Discussion

The results should be viewed as preliminary and suggestive because of the coarseness of the recognition measure of knowledge and the lack of true person by person information in the sociometric data. Still, the results do indicate that officers' knowledge of NPOs, as measured by recognition, was concentrated in their social network in a manner at least partly described by centrality. In addition, membership in local professional associations (which appears to have structural implications) and gender also were independent factors in the distribution of knowledge among contributions officers.

That gender was so strongly related to recognition was unexpected. Perhaps the women officers tended to be more interested in charity beyond the responsibilities of their jobs and connections to contributions staff in other firms than male officers, and perhaps they paid closer attention to information about NPOs in the local media. It is also possible that women officers spent more time and effort learning about NPOs on their own, apart from their ties to other officers, or that women officers used whatever ties they had with other officers more effectively in learning more about the NPOs than men.

One variable that has been difficult to disentangle from the effects of social structural position on knowledge in past research and in the present paper is the length of experience an individual has in a domain and how long an individual has been a part of the community. While both Boster (1985, 1986) and Brewer (in press) found that structural position and knowledge were related, they also noticed, as did Garro (1986), that more knowledgeable informants also had more experience in the domains and communities under investigation. Variation in officers' recognition of NPOs could very well be due to length of tenure in their jobs and/or length of residence in the Minneapolis/St. Paul area, with more experienced officers more likely to be central in the officer network. Place of birth in the data set analyzed here probably does not index officers' baseline familiarity with local NPOs (separate from their ties to other officers and job duties) very well because of residential mobility. Likewise, prior work experience in human services would probably increase an officer's recognition of NPOs only if that work experience was in the Minneapolis/St. Paul area. Another possible factor in explaining officers' recognition is that officers in some, especially more central, firms may have heard about some NPOs solely because the NPOs themselves had directed their requests for charitable donations to their firms and not others.

Some next steps in research on the social distribution of knowledge should be to collect both behavioral and cognitive sociometric data that measure the strength of dyadic ties. Such sociometric data should be coupled with domain-specific cognitive data that are appropriate for cultural consensus analysis (or some variant thereof) to measure individuals' knowledge levels. In addition, systematic data should be gathered on individuals' length of experience in the community and with the domain under investigation. A more stringent test of the centrality - cultural knowledge hypothesis also would ideally examine a community of people that has multiple subgroupings, instead of an overall core-periphery structure. Boster's (1986) findings with the Aguaruna manioc cultivators (and their kin-oriented exchange structure) suggest that centrality would still remain associated with cultural knowledge in such a multiple subgroup structure.

Acknowledgements

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Research Article

PREDICTING CLUSTERING FROM SEMANTIC STRUCTURE

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Abstract—*This study presents a process model for predicting the strength of semantic clustering within homogeneous semantic domains. The key element of the model is the assumption that clustering between adjacent items in recall is a function of their semantic similarity defined by proximity in a multidimensional space. Data from 17 word lists drawn from various homogeneous semantic domains were collected by a method that simultaneously provides interitem proximity data for similarity scaling and creates a memory list for later recall. Wide variation in the strength of semantic clustering was observed among the 17 word lists. Subjects' clustering performance was in close correspondence to predictions derived from the process model. Moreover, the degree of observed and simulated clustering across lists was strongly associated with distributional features of the semantic structure of the word lists.*

It is well known that semantic clustering occurs in a variety of free-recall tasks. For instance, subjects presented with randomized lists of words from several semantic domains (e.g., birds, occupations, and vegetables) tend to cluster the words by domain in their recall protocols (Bousfield, 1953; Bousfield & Cohen, 1955). More recently, semantic clustering has been found in the recall of a variety of word list types, with clustering measured by the correlation between interitem proximity in recall orders (aggregated across subjects) and the judged similarity of items (Caramazza, Hersh, & Torgerson, 1976; Cooke, Durso, & Schvaneveldt, 1986; Friendly, 1979; Schwartz & Humphreys, 1973).

This article extends the concept of semantic clustering from the between-domain level to the within-domain level.[1] A homogeneous semantic domain consists of a set of words (exemplars) that are all members of a superordinate category, such as fish, furniture, or vehicles. We treat association or clustering among successive items in recall within a domain as a function of judged similarity as represented in euclidean space. Bousfield noted in his 1953 article that he initially intended to study clustering within homogeneous domains but lacked the tools to measure the semantic similarity of items. Our study overcomes this problem by using the method of triads (Weller & Romney, 1988) to simultaneously present randomized items to subjects for later recall and to collect similarity judgments for scaling.

Spatial representations of the internal structure of homogeneous domains are known to relate to a number of cognitive functions. For example, distances from such models have been shown to predict categorical judgment time (Caramazza et al.,

1976; Rips, Shoben, & Smith, 1973; Shoben, 1976), completion of analogies (Rips et al., 1973; Rumelhart & Abrahamson, 1973), and reaction time to solve triadic comparison problems (Hutchison & Lockhead, 1977; Romney, 1989). As Nosofsky (1992) observed, "The beauty of deriving a similarity-scaling representation by modeling performance in a given task is that the derived representation can then be used to predict performance in independent tasks involving the same objects and stimulus conditions" (p. 26).

The preliminary task of this study was to verify that the clustering effects in the free recall of lexical items from a homogeneous domain are explained by the semantic similarity structure of the domain. Our hypothesis assumed that the free recall of items in an organized semantic domain is a sequential search process from item to item. We therefore expected that two successively recalled items would tend to be closer to each other semantically than two items selected at random. Following the demonstration that semantic clustering occurs within homogeneous domains, we develop a process model to account for differences in clustering performance among word lists drawn from various domains.

METHOD

Similarity judgments were collected for 17 lists of words from 11 domains (see Table 1). A different group of approximately 25 subjects (undergraduates at the University of California, Irvine) responded to each word list. Lists 1, 3, 5, 7, 9, 11, 13, 14, 15, and 16 consisted of the 21 most typical items from Rosch's (1975) fruit, vegetable, furniture, vehicle, weapon, clothing, bird, toy, tool, and sport domains, respectively. Lists 2, 4, 6, 8, 10, and 12 were composed of 20 items (of varying typicality) from Rosch and Mervis's (1975) fruit, vegetable, furniture, vehicle, weapon, and clothing domains, respectively, plus the item from Rosch (1975) that had the greatest typicality per domain but was not already included in Rosch and Mervis's (1975) 20 items. List 17 consisted of the 21 most frequent fish terms from Battig and Montague's (1969) norms, excluding *whale, rock,* and *shrimp*.

Similarity judgments were collected on the 21 items for each word list with triads tests (Weller & Romney, 1988). Subjects were presented with sets of three items and asked to circle the item most different from the other two. Each triad test was individually randomized with the program ANTHROPAC (see acknowledgments) using a lambda-one, balanced, incomplete block design (Burton & Nerlove, 1976). This design produces 70 triadic comparisons for the test, with each pair of items occurring exactly once and each of the 21 items occurring 10 times. The triads tests served the double purpose of measuring the judged similarity among items and presenting the items in a completely randomized fashion for the free-recall task.

Immediately after the triads tests were completed and col-

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1. Caramazza et al. (1976) examined clustering within homogeneous domains, but did so in the context of mixed-category lists.

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Table 1. *Number of subjects, mean number of items recalled, mean semantic-clustering z score, and cumulative semantic-clustering Z score, by word list*

Word list[a]	Number of subjects	Mean items recalled[b]	Mean z[c]	Cumulative Z[c,d]
1. fruit1	26	14.58	1.41	7.17
2. fruit2	25	13.80	1.05	5.24
3. vegetable1	24	12.75	0.93	4.55
4. vegetable2	28	13.50	0.74	3.90
5. furniture1	26	14.12	1.80	9.19
6. furniture2	22	13.59	0.76	3.56
7. vehicle1	24	13.92	1.55	7.60
8. vehicle2	22	13.36	0.87	4.08
9. weapon1	25	13.28	1.17	5.87
10. weapon2	21	11.38	0.66	3.02
11. clothing1	28	13.96	1.69	8.97
12. clothing2	20	14.55	0.60	2.68
13. bird	25	13.44	0.78	3.88
14. toy	26	12.42	1.08	5.48
15. tool	26	12.89	0.95	4.86
16. sport	27	14.22	1.43	7.43
17. fish	26	12.62	0.78	3.99

[a] Lists 2, 4, 6, 8, 10, and 12 included items of varying typicality. All other lists were the 21 most typical items from the domain (see text for details).
[b] A total of 21 items was possible. Extralist intrusions and repetitions were not included.
[c] All z scores reported as absolute values.
[d] For all word lists except 10 and 12, $p < .001$; for Lists 10 and 12, $p < .01$.

lected from the subjects, and without previous warning, the subjects were asked to recall, in writing, as many of the items appearing on the triads test as possible within 75 s. These protocols constituted the free-recall data.

RESULTS

For each word list, the triads data were transformed into a 21-by-21 proximity matrix, with 1 unit of similarity scored for the two items in each triad that were not circled by a subject (Weller & Romney, 1988). A single aggregated proximity matrix was formed by adding the scores for all subjects. A three-dimensional spatial representation of the similarity of items for each word list was obtained through correspondence analysis (Gifi, 1990; Greenacre, 1984; Weller & Romney, 1990). This representation depicts the judged similarity structure of each word list in terms of euclidean distance, where more similar items are closer to each other than less similar items. For the 17 word lists, the average correlation between the raw proximities and the three-dimensional euclidean distances was .73.

A subject's free-recall protocol may be conceptualized as a path through the spatial representation derived from the proximity matrix. Our hypothesis specified that on average the length of a subject's path should be shorter than expected by chance. We define a subject's path length as the sum of the euclidean distances between successive items recalled (see Fig.

1). Since subjects remembered different and varying numbers of words (subjects recalled on average a little more than half of the items; see Table 1), the expected path lengths were computed separately for each subject.[2]

A method for computing the mean and variance of all possible path lengths for a given set of points in a euclidean distance matrix using quadratic assignment is elucidated in detail by Hubert (1987; Hubert & Levin, 1976). Carroll, Romney, Farner, and Delvac (1976) independently provided computational formulas for path length statistics and showed that in a number of examples, random path lengths were approximately normally distributed. We replicated these findings with 10,000 simulations on the items in each of 12 sample recall protocols from various word lists and found that the distributions of possible path lengths were very close to normal in all cases.

We index semantic clustering by calculating a z score for each subject's observed path length for the set of words recalled by that subject. Negative z scores indicate clustering based on semantic similarity, while positive z scores indicate paths

2. Extralist intrusions, or the recall of items not on the word list, occurred in 42 (10%) subjects' recalls and were not considered in the calculation of observed or expected path lengths. When a subject's recall included repetitions (occurring in 53, 13%, subjects' recalls), the subject's observed path length was reduced by the number of repetitions (nearly always one) times the mean observed distance between two successively recalled items in the subject's path.

Predicting Clustering
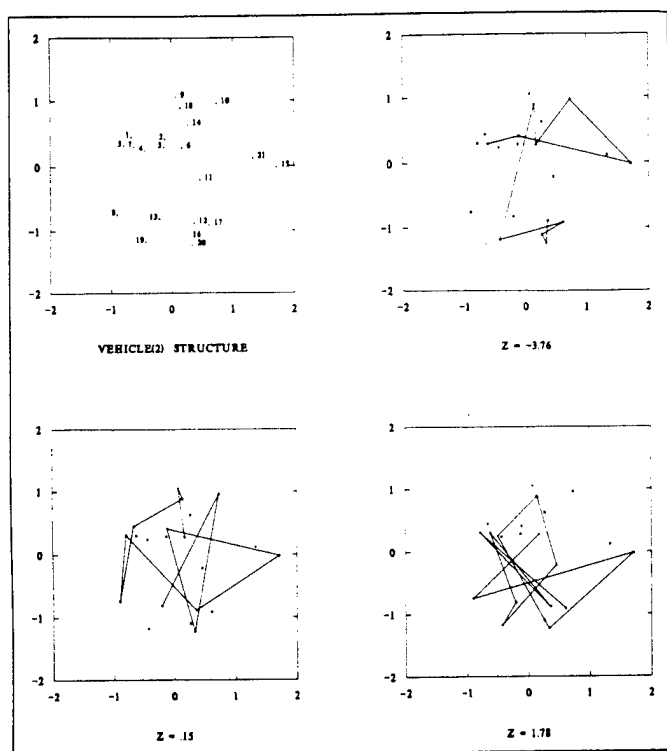
Fig. 1. Euclidean representation of the semantic structure of vehicle2 word list and examples of three free-recall paths through the structure. Key for items: 1. automobile, 2. car, 3. truck, 4. bus, 5. motorcycle, 6. train, 7. trolley car, 8. bicycle, 9. airplane, 10. boat, 11. tractor, 12. cart, 13. wheelchair, 14. tank, 15. raft, 16. sled, 17. horse, 18. blimp, 19. skates, 20. wheelbarrow, and 21. elevator.

longer than chance. By using only the words recalled by the subject, we ensure that a short path length does not occur because the subject recalls only a small clustered subset of items from the list, in which case any possible path would be short compared with all possible paths through the complete word list. The use of z scores allows comparisons among the different word lists.

Figure 1 shows a two-dimensional (three dimensions were used in all calculations) representation of the semantic structure of one word list, vehicle2 (List 8), together with 3 subjects' free-recall paths through the word list. We have exaggerated the range of paths for illustrative purposes by picking the most clustered path, with a z of -3.76; a nearly random path with a z of $+0.15$, and a scattered, nonclustered path with a z of $+1.78$. Note that the typical link in the most clustered path is short, linking items that are semantically similar. We interpret such short paths as exhibiting within-domain clustering. The scattered, nonclustered path, in contrast, links items that are relatively dissimilar from each other. Subjects with path lengths longer than expected by chance were rare.

Subjects appear able to sequentially search memory in a homogeneous domain in a manner explained by the concept of semantic similarity (see Table 1). For the 17 lists, the mean z score for semantic clustering ranged from -0.60 to -1.80. Since all group means were negative, we report the absolute

value of z scores in the remainder of this article. These results were significant for each list, as indicated by the cumulative Z scores produced by Stouffer's method of aggregation (Mosteller & Bush, 1954), with all but two lists significant at the $p < .001$ level. The cumulative Z score for all 421 subjects was 22.36. The mean Z score of all subjects was 1.09, which indicates that the typical subject's path was shorter than 86% of all possible paths for the words recalled.

We also investigated the subjects' unordered-recall protocol data for interitem dependencies. Two results emerged. First, we found that the sets of items subjects recalled were widely distributed in the semantic space. A quadratic assignment analysis (Hubert, 1987) revealed a small but significant tendency for items recalled by a subject to be more dispersed in semantic space than expected by chance. Second, analysis of aggregated item co-occurrence matrices revealed no detectable item codependencies. Singular value decomposition (Weller & Romney, 1990) of these matrices showed single-factor solutions (the ratio between first and second singular values ranged from 9.2 to 17.1, with the first factor explaining 80% to 92% of total variance). This result indicates that at the aggregate level, items appeared on protocols as predicted by a weighted (by proportion of subjects recalling an item) random sampling from the whole list.

We turn now to the question of whether there were significant differences in clustering among the 17 word lists. The most straightforward test of this question was a one-way, fixed-effect analysis of variance on the individual subjects' z scores. The results indicated that there were significant differences among subjects' performance in the 17 word lists, $F(16, 404) = 2.75$, $p < .001$. In the following two sections, we develop a model to account for these differences and relate them to a characteristic of the semantic structure, namely, the skewness of the distribution of the scaled interpoint distances for each of the 17 word lists.

A TWO-STAGE PROCESS MODEL OF SEMANTIC CLUSTERING

In this section, we develop a process model that simulates recall paths in a semantic domain. One of the assumptions of the model is adapted from a statistical model for clustering due originally to Cowan (1966) and elaborated in several useful ways by Robertson (1982, 1990; Robertson & Ellis, 1987). This model can be described as a homogeneous, withoutreplacement, Markovian sampling scheme outlined as follows.

Let X_n be a random variable denoting the nth recall from a recall protocol S consisting of N items, $n = 1,2, \ldots , N$. The basic equation of the model is

$$P\{X_{n+1} = j | X_n = i, X_{n-1} = i_{n-1}, \ldots , X_1 = i_1\}$$

$$= \frac{w_{ij}\delta_{j,n}}{\sum_{k \in S} w_{ik}\delta_{k,n}}, \tag{1}$$

where

$$\delta_{j,n} = \begin{cases} 1 & j \in S - \{i, i_{n-1}, \ldots , i_1\} \\ 0 & \text{otherwise,} \end{cases} \tag{2}$$

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and $w_{ij} > 0$ for all distinct i, j, ε, S and $n = 1, 2, \ldots, N - 1$. Equations 1 and 2 reflect the Markovian, without-replacement assumption by requiring that the $(n + 1)$st recall be from among the previously unrecalled items and dependent on the last recall, but otherwise independent of the order of past recalls. The w_{ij} can be interpreted as associative weights between items, and in application could reflect such things as co-membership in a category or, as in our model, semantic proximity.

First-item recalls are assumed to be governed by a weighted sampling rule given by

$$P\{X_1 = i\} = \frac{v_i}{\sum\limits_{j \in S} v_j},\qquad(3)$$

where $v_i > 0$ for all i, ε, S. As the model in Equations 1, 2, and 3 stands, it generates a probability distribution on all $N!$ orderings of the list of N items as a function of $N(N - 1)$ associative weights, w_{ij}, and N initial-item strengths, v_i. However, actual recall protocols are only ordered subsets of the N items, so a memory process must be added to the model.

One way to incorporate a memory process is to postulate item memory parameters, $0 \le r_i \le 1$, for $i = 1, 2, \ldots, N$. Then the list S of to-be-recalled items in Equation 1 is computed as a weighted random sample from a master list of N items, with marginal probability r_i that item i is included in the list. This particular memory process represents the case described earlier, in which subjects' unordered recalls showed no pattern of interitem dependencies.

The model augmented with the memory process now generates a probability distribution on the $\sum\limits_{k=0}^{N} \dfrac{N!}{(N - k)!}$ possible ordered-recall protocols of various lengths. For large lists, such as $N = 21$ in our experiment, it is combinatorially impossible to run enough subjects to estimate the probability distribution over all the possible ordered-recall protocols, so it is necessary to make additional assumptions in order to simulate the model for our data.

Since our key assumption was that clustering between two items in recall is a function of their semantic similarity, we decided to estimate the associative weights, w_{ij}, directly from the three-dimensional euclidean representation of the word list obtained from the subjects' triads data. Various functions making the w_{ij} a decreasing function of the interitem euclidean distances, d_{ij}, are possible (e.g., the exponential relationship described in Shepard, 1987). In our simulations, we used the simple reciprocal distance function,

$$w_{ij} = d_{ij}^{-1}.\qquad(4)$$

Since the evidence from our experiments suggested that subjects' unordered recalls can be regarded as approximating a weighted random sample from the word list, we estimated the memory probabilities, r_i, by the proportion of subjects who recalled each item. Finally, to complete the specification of the model, we made the strong assumption that the initial-item

strengths, v_i, also were set equal to the marginal recall proportions. This assumption mimics the empirical finding in our data and elsewhere (e.g., Battig & Montague, 1969) that the first item recalled tends to be one that has a high overall recall probability.

We implemented the model embodied in Equations 1 to 4 in a computer program that simulated 10,000 paths for each of the word lists. In effect, the algorithm may be characterized as follows: (1) To begin, a recall set of items is selected by including each item independently, with marginal probability estimated by the observed proportion of subjects who recalled the item. (2) The first item recalled is selected from the recall set according to Equation 3, with v_i estimated by the observed proportions of item recall. (3) The program then randomly picks the next item from the recall list proportional to the relative similarity to the previous item, with similarity defined by Equation 4. In other words, the probability of selecting any given item next is its reciprocal distance from the previous item divided by the sum of reciprocal distances from the previous item for all remaining items. (4) The program then returns to Step 3 and proceeds to sample the remaining items, without replacement, until all items selected in Step 1 have been exhausted. The algorithm is rerun until 10,000 paths of variable length have been simulated.

In order to compute z scores from the simulation comparable to the mean z scores observed in the actual experiment, we generated an expected reference distribution with a mean and standard deviation that allowed calculation of a z score for each of the model-based simulated path lengths for each word list. The appropriate comparison distribution for each of the 17 word lists was generated by a simulation of 10,000 paths replacing Step 3 above with a strictly random draw of the remaining items; that is, in effect, we set all w_{ij} in Equation 1 to the same value. Using this as a randomly generated "expected by chance" reference distribution, we calculated a mean z score for each word list in the model-based simulations.

The results shown in Table 2 include the mean observed z scores together with the mean model-based simulated z scores. The model-based simulation results were close in magnitude to those observed in human subjects. The weighted (by sample size) mean of the 17 word lists' model-based simulation z scores was 1.43, which indicates that the average model-based simulated path was shorter than about 92% of all possible paths for the particular items "remembered." The correlation between the experimentally observed and model-based simulated z scores was $r = .85$ ($p < .001$). We repeated the simulation without the memory process in Step 1 above. The correlation between these z scores (see Table 2) and the observed z scores was $r = .80$, very similar to the simulation with the memory process.

SEMANTIC STRUCTURE CONSIDERATIONS

We turn now to the question as to whether the overall semantic structure, as represented in the scaled plots, might influence clustering performance in free recall. Examination of the plots revealed that apparent differences in the semantic

Table 2. *Observed mean semantic-clustering z score, simulation z score with memory process (SM), simulation z score without memory process (S), and skewness of the distribution of interpoint distances, by word list*

Word list[a]	Observed mean z[b]	SM simulated z[b]	S simulated z[b]	Skewness
1. fruit1	1.41	1.64	2.24	−0.30
2. fruit2	1.05	1.09	1.81	0.53
3. vegetable1	0.93	1.20	1.64	−0.17
4. vegetable2	0.74	1.17	1.74	0.24
5. furniture1	1.80	1.87	2.39	−0.56
6. furniture2	0.76	1.42	2.04	0.27
7. vehicle1	1.55	1.73	2.27	−0.01
8. vehicle2	0.87	1.03	1.56	0.05
9. weapon1	1.17	1.70	2.46	−0.29
10. weapon2	0.66	0.99	1.58	1.03
11. clothing1	1.69	2.09	2.53	−0.60
12. clothing2	0.60	1.15	1.79	0.30
13. bird	0.78	1.44	1.78	0.90
14. toy	1.08	1.34	1.83	−0.10
15. tool	0.95	1.40	2.00	−0.26
16. sport	1.43	1.53	2.02	−0.41
17. fish	0.78	1.22	1.89	0.33

[a] Labeling same as in Table 1.
[b] All z scores reported as absolute values.

structure were strongly correlated with the skewness[3] of the distributions of the interpoint distances among the items in the plots.

Positive skewness characterized plots with a single dense area of many points with a few outliers. In these domains, we would expect that clustering in the core area would tend to be washed out by jumping to and from dramatically outlying points (which are relatively equidistant from points in the core cluster). Thus, clustering performance would be depressed in such cases.

Negative skewness characterized plots with two or more subgroups of roughly equal sizes. In these patterns, no matter where a long jump might occur, there are several close points in dense clusters available for the next choice that would tend to dominate the probabilities of choices in terms of similarity. Thus, clustering performance would be facilitated in such cases.

We found that the semantic structure of the word lists, as indexed by skewness, does in fact have interesting relations to the observed and simulated z scores (see Table 2). The correlation between observed z scores and skewness was $r = -.75$ ($p < .001$) and between simulated z scores and skewness was $r = -.69$ ($p < .002$). A multiple correlation analysis using both mean simulated z scores and skewness to predict the mean observed z scores did not significantly raise the .85 correlation

between mean observed and simulated scores (it went to .88). The partial correlation between mean observed and simulated scores holding skewness constant was $r = .70$, showing that skewness did not remove the relation between the simulations and the observed scores.

An overall concise perspective on these interrelationships may be gained from reference to Figure 2, a scatter plot of the 17 word lists showing the relation between observed mean z scores and simulated mean z scores. Word lists characterized by positive skewness are identified by filled circles. Some dramatic patterns emerge from the figure. First, the overall relation between mean observed z scores and mean simulated z scores is strong and reasonably linear. Second, the negatively skewed word lists with subclusters of roughly equal sizes tend to occur mostly in the upper right quadrant. Third, skewness was not a characteristic of the domain but rather of the particular word list sample from the domain. Note that in five of the six pairs of word lists drawn from the same domain, the two members of the pair are in opposite quadrants of the plot. Fourth, these five cases (fruit, furniture, vehicle, weapon, and clothing) stand out in other respects. For these five pairs, the word lists in the upper right quadrant were the 21 most typical items as defined in Rosch (1975). These lists were also characterized by negative skewness. In contrast, word lists from the same five domains in the lower left quadrant were words of varying typicality from Rosch and Mervis (1975). These lists displayed positive skewness due to the tendency for their semantic structures to have outliers.

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3. Skewness is defined as the ratio of the third central moment to the cube of the standard deviation.

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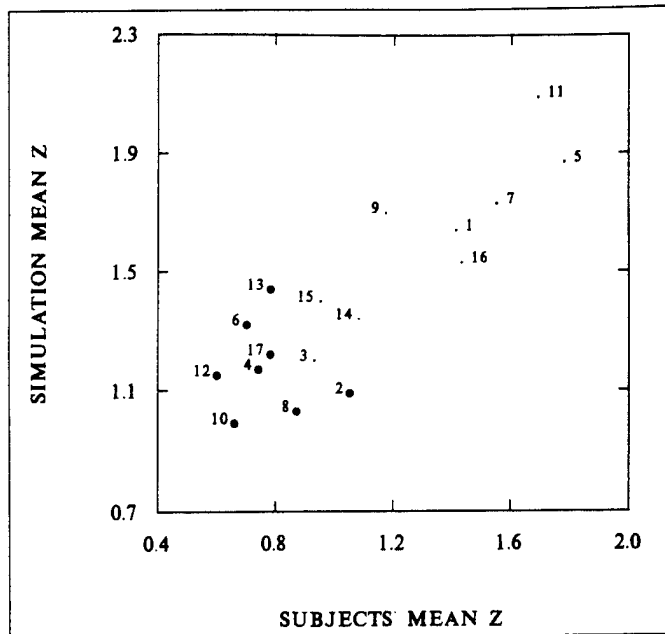
Fig. 2. Relationship between the mean observed subjects' z scores (x-axis) and the mean model-based simulated z scores (y-axis) for the 17 word lists. Word lists with positive skewness are shown as filled circles. Key for word lists: 1. fruit1, 2. fruit2, 3. vegetable1, 4. vegetable2, 5. furniture1, 6. furniture2, 7. vehicle1, 8. vehicle2, 9. weapon1, 10. weapon2, 11. clothing1, 12. clothing2, 13. bird, 14. toy, 15. tool, 16. sport, and 17. fish.

DISCUSSION

In this article, we have demonstrated a way to measure semantic clustering within homogeneous semantic domains. Subjects showed a consistent tendency to use "short" paths through a spatial representation of the items. Our additional finding that the unordered-recall lists were like a weighted random sample of the word lists is at variance with clustering studies with mixed-category lists. For example, statistics like Tulving and Pearlstone's (1966) items per category and number of categories and Batchelder and Riefer's (1986; Riefer, 1982) storage and retrieval parameters were proposed to integrate the pattern of nonrandom co-occurrences of item recalls from mixed-category lists. Even though our domains were highly structured, the structures did not lead to clustering in recall as measured by co-occurrence patterns.

The recall paths used by our subjects revealed a strong tendency toward clustering of adjacent items, which suggests that the semantic structure of the word list had a large influence on retrieval strategy. In fact, all the evidence for clustering that we obtained occurred in subjects' ordered recalls. We speculate, as a matter for further work, that in homogeneous semantic domains, the domain structure facilitates memory retrieval but does not greatly influence episodic memory storage.

The process model we developed to account for the differences among word lists was based on the notion that, once started on the free-recall task, successive recalls represent choices among the "remembered" items as a function of inter-

item similarities. The simulated results from the model closely fit the behavior of the subjects. The fact that the subjects' behavior and the simulation results were related similarly to the skewness variable greatly strengthens the validity of the model.

The overall semantic structure of a word list strongly affected both observed and simulated clustering performance. The skewness of the interpoint distances only partially indexed structural differences among word lists since it did not add independent information in predicting observed scores, nor did it remove the association between the observed and simulated scores.

One next step in developing the model would be to obtain enough data on a domain to estimate the w_{ij} and the v_i in Equations 1, 2, and 3. Then it might be possible to determine more rationally the function connecting distance to associative strength in Equation 4. Another step in developing the model would be to measure the interresponse times for items occurring adjacently in the free-recall task (compare Mandler, 1970; Patterson, Meltzer, & Mandler, 1971; Pollio, Richards, & Lucas, 1969). Associations involving high-similarity pairs should occur more rapidly than associations involving low-similarity pairs. We expect that the function relating interresponse time interval to similarity may be a log function. A further suggestion for future research is to reexamine, with our approach, Bousfield's (1953) finding that clustering is greater during earlier stages of recall than in later stages.

This study contributes additional evidence for the psychological validity of spatial representations derived from scaling judged-similarity data. The fact that a number of cognitive functions can be predicted so well from these representations illustrates their usefulness in cognitive science and their potential for wider application. It remains for future investigations to establish an optimal representational model for similarity as well as the appropriate function relating similarity to strength of clustering between adjacent items in the recall task.

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the requirements for the degree of

DOCTOR OF PHILOSOPHY

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Devon Duffield Brewer

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ABSTRACT OF THE DISSERTATION

Patterns in the Recall of Persons

by

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Doctor of Philosophy in Social Science

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This dissertation describes three studies on the
organization of persons in memory. Individuals in a
graduate academic program, a Taiwanese Christian fellowship,
and a public affairs department of a university free listed
the names of persons in their respective communities. Three
types of response patterning were examined in subjects'
recalls: association, frequency, and serial order.
Associative patterns refer to the connections or
relationships between adjacently recalled persons.
Frequency patterns refer to which persons are recalled, and
serial order patterns refer to which persons are remembered
earlier or later in recall.

In the graduate academic program, subjects tended to
cluster (mention adjacently) persons in recall by cohort
(year in the program). Subjects' frequency and serial order
patterns showed that persons in cohorts chronologically

close to a subject were more likely recalled and recalled earlier than persons chronologically distant from a subject.

In the religious fellowship, subjects clustered persons in terms of perceived social proximity. That is, pairs of persons recalled adjacently by a subject were perceived to be much closer socially than would be expected by chance. Regarding frequency patterns, the persons recalled by a subject tended to be socially closer to that subject and more visible in the fellowship than those persons not recalled. Subjects' serial order patterns demonstrated that more visible persons tended to be recalled earlier than less visible persons.

In the public affairs department, subjects clustered persons by perceived work proximity. In other words, pairs of persons recalled adjacently by a subject were perceived to work more closely with each other than would be expected by chance. Subjects' frequency and serial order patterns showed that the persons most likely recalled were the most visible in terms of regular physical presence and that higher status persons tended to be recalled earlier than lower status persons. In these studies, pairs of adjacently recalled persons were mentioned most rapidly in succession if they were in the same cohort, perceived to be socially close, and perceived to work closely, respectively.

This research indicates that the underlying cognitive
structure of persons in a community is based on the
community's social structure.

INTRODUCTION

This dissertation consists of three studies (Chapters 1
to 3) on patterns in the recall of persons and a concluding
discussion section (Chapter 4). Chapter 1 introduces this
line of research and provides a comprehensive review of the
literature on the topic, in addition to reporting the first
study. This chapter was published as an article in _Social
Networks_ in 1993, volume 15, issue number 4, on pages 335 to
359. Chapter 2 is in press as an article in _Social
Networks_. Earlier versions of Chapter 3 were presented at
various conferences and the paper, as it appears here, is
currently under review (see curriculum vitae). Chapter 4
represents the last half of a paper ("The social structural
basis of the organization of persons in memory") which was
presented at a conference and is also currently under review
(see curriculum vitae). The first half of this paper
summarized the studies reported in Chapters 1 to 3. The
portion included as Chapter 4 discusses the results of the
three studies in the context of many areas of research and
offers a theoretical account for the findings in this
dissertation.

Chapters 1 to 4 differ from the their counterpart
papers in terms of page, figure, and table numbering and
appendix indexing. The bibliographies of each paper are
contained in one common reference section beginning on page

165. In addition, the abstract for each individual paper has been deleted, replaced by the overall abstract of the dissertation. Moreover, the chapters in this dissertation are cited as in the original papers. Thus, Brewer (1993) refers to Chapter 1 and Brewer and Yang (In press) refers to Chapter 2. These papers are not listed in the references since they are included in the dissertation and referenced in the curriculum vitae.

The QuickBASIC program code in Appendix C is for the control analysis of clustering procedure described in Chapters 2 and 3.

CHAPTER 1

PATTERNS IN THE RECALL OF PERSONS

IN A STUDENT COMMUNITY

This paper investigates patterns in the recall of the names of persons in a contemporary, socially bounded community by people who are members of that community. The recall of persons' names is a relatively unexplored area of research. Although the recall of persons' names may involve influences not present in the recall of other stimuli, some general principles of memory may still be common to both kinds of recall. There is a long tradition in cognitive psychology of using free recall to study the organization of memory. Since experience with a given set of stimuli has been suggested as the basis for organization in memory (e.g., Mandler, 1979), it would be expected that current members of a socially bounded community would have organized cognitive representations of community members as revealed in the free recall of community members' names. Furthermore, to the extent that individuals have similar experiences with others in the community, community members should have common patterns in their recall of persons' names.

There are three types of response patterning in the recall of persons' names that will be examined: association, frequency, and serial order. Associative patterns occur to

3

the extent that persons recalled consecutively tend to be more related to each other in some way (e.g., by social interaction or sharing some individual characteristic such as gender) than persons not recalled consecutively. Frequency patterns refer to differences in the likelihood that particular persons or some types of persons are recalled. Serial order patterns are tendencies for particular persons or some types of persons to be remembered earlier or later in recall.

After reviewing the literature that relates to each of these three types of response patterns in the recall of persons' names,[1] this paper examines the associative, serial order, and frequency patterns in the recall of persons' names among members of a graduate student community.

Associative Patterns

Research on the free recall of lexical items demonstrates the generality of associative structures and processes in memory. Semantic clustering, or the tendency for semantically related items to occur together (adjacently) in free recall, has been widely documented in several variations of the free recall task and for different word list types (e.g., Bousfield, 1953; Mandler, 1970; Romney, Brewer, & Batchelder, 1993; Schwartz & Humphreys, 1973) and observed cross-culturally (e.g., Scribner, 1974), in two year-old children (Rossi & Rossi, 1965), in deaf

subjects (Liben, Nowell, & Posnansky, 1978), and in a chimpanzee (Buchanan, Gill, & Braggio, 1981). In contrast to semantic clustering, other research indicates that the alphabetic/acoustic similarity of words does not play a role in organizing free recall when there is some sort of semantic organization to the word lists recalled and has only a very minor effect when no such organization is present (Dolinsky, 1972; Lauer & Battig, 1972). Semantic similarity, then, seems to be the primary basis for associative patterning in the free recall of lexical items, although subjects may be able to recall items by alphabetical association or in terms of progressively increasing size if directed to do so (Gronlund & Shiffrin, 1986).

Associative patterns in the recall of persons' names, however, may involve one or more of four general kinds of structures: relational structures, individual characteristics, location, and alphabetic/acoustic similarities of names.

Relational Structures. Associative patterns in the recall of persons' names may be based in part on the social relations among persons. Perhaps the most broadly salient relation is interpersonal interaction. People can report quite accurately (in comparison to observed patterns of interaction) on the global social structures of the socially bounded communities in which they are involved (Cairns,

Perrin, & Cairns, 1985; Freeman, Freeman, & Michaelson,
1989; Webster, 1992). One interpretation of these findings
suggests that knowledge of affiliation patterns (i.e., who
is friend and who is foe) offers competitive advantage over
others and thus humans' (and other species') ability to
perceive social structure accurately would be an
evolutionary result of this selection process (Freeman, et
al., 1989; see also Cheney, Seyfarth, & Smuts, 1987;
Krackhardt, 1990; Lachman & Lachman, 1979).

There is some evidence that suggests, at least partly,
that people remember others in terms of interaction/
affiliation patterns. In his study of college students'
recall of the names of persons they had met during their
lifetime (including relatives, friends, and acquaintances),
Riegel (1973) noticed that subjects tended to mention
successively persons they first met in the same year. This
chronological clustering might reflect recalling persons
according to the different social contexts in which subjects
had participated (e.g., family, neighborhood, high school,
college, etc.). Along these lines, Bond, Jones, and
Weintraub (1985), Bond and Brockett (1987), and Fiske (n.
d.) found that when people free recall acquaintances the
persons remembered are strongly clustered according to
social context (e.g., family, dormitory, church, etc.), as
well as social role (e.g., teacher) and relationship mode
(Fiske, n. d.).

Williams and Hollan (1981) analyzed four high school graduates' recalls of their high school classmates from nine one-hour interview sessions in which subjects were asked to think aloud during recall. The length of time since graduation for these subjects ranged from four to nineteen years. They found that subjects used several different strategies in recalling the names of their former classmates. Two of these strategies were remembering persons by group affiliations shared with the subject and general association. Williams and Hollan (1981) defined general association as ". . . starting with a known person and searching for people who are directly related in some obvious manner (e.g., a friend, cousin, brother or sister). Occasionally a particular person will suggest a group of people (e.g. a social clique)" (p. 106). They also noticed that "every subject used the strategy of general association at one time or another. Indeed, it appeared that most subjects began their recalls with this strategy" (p.106). These first general associations produced the densest retrieval (in terms of persons mentioned per unit of time) of classmates' names.

In addition, Freeman, Romney, and Freeman (1987) observed who attended a weekly departmental colloquium series at a university over a few months. After the last meeting, they asked those who attended the last meeting to name all the people that went to the last colloquium. The

proximities of persons in recall for "in-group" informants (those directly involved in the program sponsoring the series) clearly revealed an in-group/out-group structure, while the recalls of "out-group" informants' (who were not directly involved with the sponsoring program and attended few colloquia) were not characterized by any such pattern.

Relations other than interaction, friendship, or communication could also relate to associative patterns in the recall of persons' names. For instance, when people recall their kin, genealogical tree structures and kin classes play a role in associative patterning (Alexander, 1976; Hammel, 1984; Sanday, 1969).

Individual Characteristics. In every community, some individual characteristics of persons are more important in differentiating members of the community than other characteristics. Examples of this general statement abound in the anthropological and sociological literature. A few studies have examined how the recall of persons' names relates to the persons' traits. Bahrick, Bahrick, and Wittlinger (1975) studied high school graduates' recall of their high school classmates' names. Subjects were allowed to recall for up to eight minutes. They examined associative patterns for two subsets of subjects, one composed of recent graduates (approximately a month since graduation) and the other consisting of much older graduates (approximately 48 years since graduation), and noticed

significant clustering by gender in their recall of
classmates. As Bahrick, et al. (1975) noted, it is not
clear whether this clustering by gender reflected
association by gender or was a byproduct of association by
social interaction patterns, since most social interaction
among high school students is with same-gender peers.

The individual traits of persons also were involved in
Rubin and Olson's (1980) study of college seniors' recall of
their college professors. Subjects' recalls displayed
strong clustering according to professors' academic
disciplines. Whitten and Leonard (1981) examined college
students' recall of their preuniversity teachers. Although
subjects were directed to use particular memory search
strategies, their "thinking aloud" protocols indicated that
retrieval of names was aided by focusing on a particular
academic subject (different teachers teach different
subjects in most U. S. junior and senior high schools) for
self-cueing recall of teachers' names.

Bond and Brockett (1987) observed weak, but
significant, clustering according to persons' personality
characteristics within their subjects' social context
clusters. Fiske (n. d.) also found weak overall clustering
in his subjects' recalls of acquaintances according to such
individual characteristics of persons as gender, race, and
age. It was not clear, however, whether these clustering
patterns were spurious, since both personality and other

individual characteristics tend to be unevenly socially
distributed in contemporary, socially bounded communities
(Arabie, 1984; Breiger & Ennis, 1979; Iannucci, 1992).

Location. In many communities, persons tend to inhabit
particular spatial/geographic locations, such as an office
in a building, a bunk or room in group living quarters, a
home in a neighborhood or village, or a certain part of a
classroom, playground, workshop, market, or common meeting
area. Since persons in a community are often found in these
locations, schematic cognitive representations of them might
in some cases serve as the basis for associative patterns in
the recall of persons' names. At least one of Williams and
Hollan's (1981) subjects used a locational retrieval
strategy in recalling former high school classmates by
systematically searching a mental map of where classmates'
homes were located. This subject, however, apparently did
not begin to utilize this strategy until the second hour-
long session of the recall interview. Whitten and Leonard
(1981) also observed that subjects sometimes used location-
based retrieval strategies in recalling the names of their
teachers.

Alphabetic/Acoustic Similarities of Persons' Names.
While there does not appear to be a major role for
alphabetic or acoustic similarity in the undirected free
recall of lexical items, there is some evidence to suggest
that when persons' names are recalled, the similarity of the

names in terms of their alphabetic and acoustic properties
can influence associative patterns. This ability might be
expected since there are fewer names than there are persons
and because records of persons in communities frequently are
organized alphabetically (e.g., rosters, telephone books).
Rubin and Olson (1980) found that in exception to their
subjects' overall clustering by academic discipline,
subjects tended to recall adjacently professors who had the
same last name, but taught in different fields (there were
two pairs of same last name professors). Also, Williams and
Hollan's (1981) subjects systematically self-prompted
themselves with alphabetic cues for recalling classmates'
names. This strategy, though, was used only after several
hour-long sessions of the recall interview had been
completed. Furthermore, both Fagan (1992) and Fiske (n. d.)
noticed that in the recall of high school classmates and
acquaintances, respectively, subjects displayed a tendency
to recall successively persons whose names were the same.

Frequency Patterns

Frequency patterns refer to differences in the
likelihood that some persons or types of persons are
recalled. Riegel (1973) observed that those persons whom
subjects had first met at college and ". . . during the
first year of life" (p. 356), such as family, were most
frequently mentioned in subjects' recalls of all the persons

they had met. These types of persons might be considered those people with whom subjects were most currently and strongly involved. Across all 392 subjects who participated in their study, Bahrick, et al. (1975) demonstrated that those classmates who were later identified by subjects as close friends or romantic interests were much more likely to be recalled than those considered friends or acquaintances.

Sudman (1988) found that the likelihood of recalling neighbors was positively related to the strength of social tie (acquaintance, friend, close friend) and spatial proximity between respondents and their neighbors. Somewhat paradoxically, however, Sudman (1985) reported that in several different church, social, and work communities, acquaintances were either no less or even more likely to be recalled than friends or close friends.

Freeman, et al. (1987) showed that "in-group" and "out-group" informants differed in which persons they recalled as attending the last colloquium meeting. The recalls of "in-group" informants were biased towards the long-term attendance pattern, while the recalls of "out-group" informants were more accurate about who attended that specific event.

Serial Order Patterns

Systematic tendencies for some persons or types of persons to be recalled earlier or later in recall, or serial

order patterns, also may exist in the recall of persons' names.[2] For instance, Fararo (1963) asked people who were involved with community decisions in a city to name the people involved with particular community issues. Although not directly indicated in his results, one possible interpretation of his data suggests that the most frequently named and most prominent figures involved with an issue tended to be mentioned first, followed by the persons in the subject's own political faction, and then persons seemed to be named at random. In addition, Riegel (1973) found that parents tended to be listed first or early in subjects' recalls of all the persons they had ever met.

Hammel (1984) demonstrated that there were strong serial order patterns in Serbian informants' recall of kin. Subjects varied, however, in the specific dimensions of serial ordering, such as listing male kin earlier than female kin, ascending generations before descending generations, and/or live kin before dead kin (several other serial order patterns also were observed).

Viewed as a whole, the research just reviewed suggests that the memory of persons is organized and that this organization is displayed in free recall. However, most of these studies have not focused on the recall of persons from the same contemporary, socially bounded community by members of that community, and those that did have not given a comprehensive empirical treatment of the three types of

response patterning. The main purpose of this study is to provide a detailed analysis of the recall of persons in such a community in order to develop further the understanding of how the memory of persons is organized.

Method

Ethnographic Background

The community studied was the graduate student body of the Social Relations program at the University of California, Irvine. As of Winter quarter, 1992, there were 41 students officially enrolled in the program, including 28 females and 13 males. Some age and ethnic diversity existed among the students and a number of students came from foreign countries. Students all had different first and last names from each other, except for two persons who went by variants of the same first name (an example comparable to this case would be the names Joseph and Joe).

The graduate program is an inter-disciplinary program run mainly by anthropology and sociology faculty. All graduate students in the program were pursuing doctoral degrees. Students took approximately seven to nine years to complete a degree in the program and there was some attrition. The first two years of study in the program were focused on completing program course requirements. Each cohort of students (i.e., students who entered the program

in the same year during Fall quarter) took a series of classes together over the first year or two (depending on what point in the program's history) that was explicitly designed to guide students through the initiation and completion of research that resulted in papers roughly equivalent to master's theses. Enrollment in this series was restricted to students in that cohort. Also during the first few years of study in the program, students took required core courses involving students in their first three years of study in the program. In addition, students took elective courses that included students at various stages of progress in the program. The numbers of students in each of the nine cohorts (from most junior to most senior) were 4, 9, 6, 5, 7, 5, 3, 1, and 1.

Students, as well as faculty, were quite diverse in terms of their academic interests. This differentiation was reflected by different students working formally and informally with different faculty members, sometimes from different departments. In some cases, there were several students associated with one or a set of faculty members. In some of these cases, the students also worked with each other, for example, as in a large research project. Students who were teaching assistants (most students were at one point or another during their studies) had another institutional context for interaction with other students and faculty.

Students were assigned office space in two large, multi-story buildings in the Social Science complex of the campus. These offices ranged widely in size, housing anywhere from one to over three dozen students, and were distributed across many floors of these buildings. Initial office assignments were arbitrary and made without reference to the student's program, cohort, or any other characteristic. Usually by the third year, students managed to locate office space near or share space with other graduate student friends (not necessarily in the same program, although largely so). Students varied in how much time they spent in their offices, from not at all to several hours each day. Advanced students who were conducting fieldwork or on leaves of absence rarely came to the campus.

Informal social interaction among first-year students tended to be within their own cohort. Faculty emphasized to incoming students that their primary source of social support in the program would be the students in their cohort. As students advanced further in the program, informal social ties and friendships tended to become more based on shared academic interests, experiences (e.g., as with office mates, fellow teaching assistants, etc.), and other factors.

Informants

     Informants were 15 graduate students from the program,
including 12 females and 3 males, and students from each of
the five most recent cohorts (from first to fifth year
students) (see Table 1.1). Aside from the absence of very
senior students, this sample appeared to be quite
representative in terms of students' demographic
characteristics, academic interests, and office locations.

Procedure

     Informants were interviewed individually during Spring
quarter, 1992. Two informants who were available were
reinterviewed for the same recall task two to three weeks
after the first interview in order to assess the reliability
of recall patterns. The interview was administered via
microcomputer with a standard keyboard layout. In the
interview, the first screen presented to a informant
consisted of an introduction to the experiment and
instructions for how to respond on the keyboard. I then
reviewed these instructions with the informant orally. The
next screen showed the question, "Who are all the graduate
students in the Social Relations program? (You can use their
first and/or last names and you do not need to put your name
as a response)."[3] No instructions were given regarding the
order in which informants were to list names. Several lines
below the question, the cursor would be blinking and

informants could type names which would be displayed on the screen. After typing a name, informants were to hit the Enter key, which would cause the name to disappear from the screen and the blinking cursor to return to its original position below the question. Then informants could type in additional names, each time hitting the Enter key after typing a person's name. Informants were given up to ten minutes to recall as many persons as they could, but all informants finished within 107 to 382 seconds (i.e., less than seven minutes), saying that they could remember no more.

Since the recall of persons was the only task informants performed, their patterns in recall are not confounded by any short-term memory processes introduced by preceding tasks and thus their response patterns were thought to reflect long-term memory structures and processes.

Two types of recall data were extracted from these responses. First, the recall order of all the names mentioned by a informant was obtained. Second, the time (precise to a hundredth of a second) at the strike of the first letter, last letter, and Enter key for each name was recorded for every informant's recall. Cohort information for each of the 41 students in the program was obtained from the School of Social Sciences' graduate advisor.

Results

On average, informants recalled approximately half of the students in the program (see Table 1.1) and all of the 41 students in the program were recalled at least once. Three informants mentioned themselves and two informants repeated a person in recall. Three informants recalled two persons not in the program, one informant recalled four persons not in the program, and one informant mentioned a name that was not recognizable. Of these intrusions, three persons had once been in the Social Relations program but had since transferred to different graduate programs, one had taken several classes in the Social Relations program even though enrolled in another program, and another was not connected to the program at all. Self-mentions, repetitions, and intrusions are not included in the total numbers of persons recalled in Table 1.1.

Association

Nearly every informant's recall exhibited clear associative structure. Initial inspection of informants' recall orders suggested that informants were clustering their recall of fellow students by cohort. This impression was tested with a clustering measure developed by Hubert and Levin (1976) based on quadratic assignment. The cohort structure was represented in a matrix where the only

distinction made among the students was whether a pair of students were in the same cohort or not. This was coded as a 41 X 41, symmetric, binary cohort person by person matrix, in which a cell had a "1" if a pair of persons was in the same cohort, and "0" otherwise. An informant's recall order can be considered as a path through a complete graph representation of this cohort structure matrix, where each link (or edge) in the graph takes a value (1 or 0) corresponding to the cell in the matrix for that pair of persons. The number of links in the path is equal to number of persons recalled minus one and the length of an informant's path is defined to be the sum of the link values for the adjacently recalled pairs of persons. Self-mentions and intrusions were not included in informants' recall paths. When a informant repeated a name, the observed path length for clustering analysis was computed to be the total path length (including the repetition) minus the mean link value for the total path.

Clustering is specifically indexed for each informant by a z-score which is the difference between the observed path length and the expected by chance (mean) path length for all possible paths among those persons recalled (i.e., for all permutations of the recall order), divided by the standard deviation of path lengths for all possible paths among those persons. In this case, paths longer than expected by chance indicate clustering. Clustering z-scores

were computed separately for each informant for just the set

of persons recalled by that informant. The distribution of

all possible paths among the set of persons recalled by a

informant was not always approximately normal. Therefore,

more sensitive, nonparametric probability values for the

significance of clustering were estimated by simulating

10,000 random paths, for each informant, for the set of

persons recalled and noting the proportion of path lengths

that were at least as large as the informant's observed path

length. To give a perspective on the magnitude of

clustering, Adjusted Ratio of Clustering (ARC) scores

(Roenker, Thompson, & Brown, 1971) were computed. This

measure equals the (observed path length - expected path

length) / (maximum possible path length - expected path

length), ranges between -1 and 1, and takes a value of 0 for

expected by chance clustering and a value of 1 for maximum

clustering.

The clustering $\underline{z}$-scores, proportions of random paths

that were as large, and ARC scores for each informant appear

in Table 1.1. Informants displayed strong and highly

significant clustering according to the binary cohort

structure. Informant 7's recall, for instance, was

maximally clustered by cohort. In other words, informants

were very likely to recall persons in the same cohort

consecutively. Interestingly, first year students, who had

only been in the program for about seven months, and other

junior students did not differ noticeably from senior students in the degree of clustering or number of persons recalled as shown by nonsignificant results from various statistical tests. Also, the two persons whose first names were variants of the same name were in different cohorts three years apart and were never recalled adjacently.

Other evidence indicates that the cohort structure describes some of the associative patterning in informants' recalls. Two informants spontaneously remarked during the recall interview that they were remembering persons by cohort. Another informant counted on her fingers during the recall interview as if mentally enumerating persons in a cohort. In addition, the two informants who did the recall interview twice showed marked increases in clustering by cohort at retest (see Table 1.1).

Furthermore, the inter-response times (IRTs) between adjacently recalled persons who were in the same cohort (within-cohort IRTs) were shorter than the IRTs between adjacently recalled persons who were in different cohorts (between-cohort IRTs). Excluding those pairs of adjacently recalled persons which involved self-mentions and persons not in the program, the amount of time elapsed between the strike of the last letter of one person's name and the strike of the first letter of the next person's name was computed for every pair of adjacently recalled persons in each informant's recall. The within-cohort IRTs were

Table 1.1. <u>Informants' cohort years, numbers of persons</u>
<u>recalled, cohort clustering z-scores, proportions of</u>
<u>simulated random paths as large as observed, and ARC scores</u>

Informant	Cohort	# recalled	Clustering $\underline{z}$	Prop. as large	ARC
1	1	23	6.15	<.0001	.67
2	1	17	3.98	.0140	.49
3	1	14	7.56	.0044	.78
4	2	26	7.40	<.0001	.74
5	2	26	4.36	.0008	.43
6	2	26	4.99	.0003	.48
7	2	17	7.24	<.0001	1.0
8	2	12	3.59	.1456	.38
9	2	18	5.61	.0001	.72
10	3	28	6.42	<.0001	.59
11	3	16	2.31	.0839	.35
12	4	19	1.15	.2072	.14
13	4	19	4.10	.0034	.50
14	5	20	5.35	.0001	.62
15	5	13	3.52	.0452	.47
	Mean	19.6	4.92		.56
	Median			.0008	
	Cumulative Z^a		19.04		
Retest					
9	2	16	7.12	<.0001	1.0
13	4	24	8.22	<.0001	.85

[a]From Stouffer's method of aggregation (Mosteller & Bush, 1954).

shorter on average than the between-cohort IRTs for 13 of the 15 informants, and these differences, when aggregated over informants, were significant (cumulative Z for individual informants' t scores was -3.66, p <.001, mean eta = .23) (Rosenthal, 1991; Winer, 1971). Very similar results were obtained when Mann-Whitney tests were calculated, when the IRTs were based on the elapsed time between the strike of the Enter key and the first letter of the next person's name, and when log transformed IRTs were used (to make the positively skewed within- and between-cohort IRT distributions more normally shaped).

On the basis of all of these results, it seems legitimate to conclude that the cohort structure provides a good description of each informant's associative patterning. Since this was the case, it was fair to aggregate data regarding associative patterns across informants. Aggregation here allows the visual representation of associative patterns. To this end, an aggregated data matrix was constructed from informants' recall orders after self-mentions, intrusions, and repetitions had been removed. A 41 X 41 symmetric person by person matrix was created for each informant where a cell representing a pair of persons held a "1" if these persons were adjacent in recall, and "0" otherwise. Diagonal values were "1" if that person was recalled by that informant, and all cells representing a pair of persons that did not both occur in that informant's

recall contained zeros. These individual matrices were
added to arrive at a single aggregated adjacency matrix.
The rows and columns referring to the six persons recalled
only once were deleted from this aggregated matrix.

This 35 X 35 adjacency matrix was scaled with
correspondence analysis (Gifi, 1990; Weller & Romney, 1990).
A two-dimensional representation of the adjacency matrix,
accounting for 22.9% of the variance, appears in Figure 1.1.
The numbers plotted denote the cohort years of persons. In
the figure, the closer two persons are, the more frequently
they were recalled consecutively. The cohort structure is
clearly exhibited for the first few cohorts and higher
dimensions did not provide more differentiation among the
senior cohorts. The lack of strong clustering of persons in
more advanced cohorts in the figure may be due the
underrepresentation of informants from those cohorts, since
more junior students may not know exactly which cohort those
persons belong to, even though these informants may know
that these persons are senior students and cluster them
accordingly in recall.

In fact, informants were less likely to cluster by
cohort persons from cohorts which were chronologically
distant from themselves, as opposed to persons in their own
or chronologically close cohorts. For each informant, the
number of observed within-cohort adjacencies and the maximum
possible number of within-cohort adjacencies were computed

Figure 1.1. Two-dimensional correspondence analysis
representation of adjacencies in recall orders. Numbers
represent cohort years of persons.
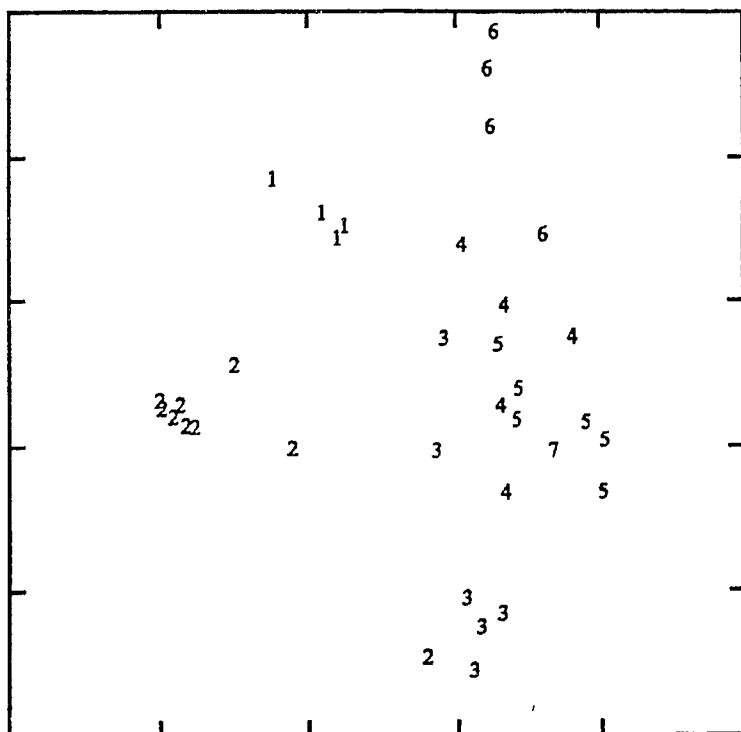
for each cohort in which two or more persons were recalled. Then, the number of observed within-cohort adjacencies was divided by the maximum possible number of within-cohort adjacencies for cohorts of zero (informant's own cohort), one, two, and three or greater years distance from the informant's cohort. These proportions, averaged across informants, were .80, .57, .36, and .43, for cohort distances of zero, one, two, and three or greater years, respectively, and the differences were significant ($\underline{F}$(3,48) = 5.46, $\underline{p}$ <.01).

Frequency

Inspection of informants' recall orders suggested that the cohort structure also influenced frequency patterns. It appeared that informants were more likely to recall persons in their own and chronologically close cohorts than persons in chronologically distant cohorts. To test this hypothesis, Goodman and Kruskal's (1954) gamma was computed for each informant between the proportion of persons recalled from each of the nine cohorts (self counted as a response in the informant's own cohort) and the absolute value of ordinal cohort distance (i.e. years) from the informant for each of these cohorts. These results appear in Table 1.2. Informants were very likely to recall all or nearly all persons in their own cohorts, with the proportion of persons recalled in other cohorts tending to decrease as the cohort

distance from the informant increased. Informants also did not recall persons from every cohort, but tended to mention at least one person from about six of the nine cohorts (see Table 1.2). Two cohorts (eighth and ninth year students), however, only had one person each.

The tendency to recall persons close to one's own cohort is also shown by another piece of evidence. An ordinal distance cohort structure matrix was created which reflects the distance, in terms of years, between persons according to the year of their cohorts. This was coded as a 41 X 41, symmetric, ordinal cohort distance person by person matrix, where a cell represents the absolute value of the difference in years between a pair of persons' cohorts. The persons recalled (unordered) by an informant tended to be more concentrated (not dispersed) in the ordinal distance cohort structure than would be expected by chance, as measured by z-scores from normal approximations of Hubert and Schultz's (1976) quadratic assignment procedure (see Table 1.2).

The similarities between the unordered recalls of the first and second interviews for informants 9 and 13 reinforce these findings on frequency patterns. Over both interviews, informant 9 mentioned 19 unique persons, 15 of whom were common to both interviews (Jaccard coefficient = 15/19 = .79). Informant 13 mentioned 26 unique persons over the two interviews, with 17 of these in common between the

Table 1.2. Informants' gamma coefficients for frequency (F)
and serial order (SO) patterns according to cohort distance,
numbers of cohorts in which at least one person was
recalled, and dispersion z-scores according to ordinal
distance cohort structure

Informant	Gamma - F	Gamma - SO	# Cohorts	Dispersion $\underline{z}$
1	-.70	.78	7	-2.06
2	-.73	.19	5	-2.02
3	-.81	.67	6	-2.42
4	-.88	.73	7	-2.91
5	-.81	.54	6	-4.02
6	-.46	.68	7	-1.24
7	-.93	.55	5	-3.91
8	-.58	.32	4	-2.25
9	-.72	.72	5	-3.04
10	-.76	.22	7	-2.20
11	-.83	.54	4	-4.03
12	-.77	.08	5	-3.16
13	-.52	.10	6	-0.83
14	-.36	.35	7	-0.44
15	-.85	.40	5	-2.30
Mean	-.71	.46	5.7	-2.46
Retest				
9	-.69	.84	6	-2.14
13	-.87	.24	7	-2.50

two interviews (Jaccard coefficient = .65). Those persons who were recalled in one interview but not the other were never in the informant's own cohort. Also, the number of persons recalled was approximately the same for both interviews. Informant 9 recalled 18 and 16 persons in the first and second interviews, respectively, and informant 13 recalled 19 and 24 persons in the first and second interviews, respectively.

Serial Order

Since both associative and frequency patterns were based on the cohort structure, it seemed likely that serial order patterns, if any existed, might also be based on the cohort structure. Examination of informants' recall orders suggested that informants tended to recall persons in their own cohort first, then persons in the cohort immediately preceding or following (in chronological terms) their own, and persons in cohorts distant from their own (regardless of chronological direction from the informant) later in recall. These impressions were tested by measuring the degree of association between the output serial position and absolute value of ordinal cohort distance from the informant for each person recalled. Goodman and Kruskal's (1954) gamma was computed between these variables for each informant and the results are presented in Table 1.2. All informants' coefficients were in the expected direction and indicate a

moderate degree of association. The effect of cohort
distance from the informant on serial position also was
examined at retest for the two informants who performed the
recall task twice. The tendency to remember persons in
one's own cohort first and persons from more distant cohorts
later in recall increased at retest for these two informants
(see Table 1.2). To test for the correspondence in the
serial orders of persons mentioned in both the first and
second interviews, Goodman and Kruskal's (1954) gamma, which
in this case is also Kendall's (1938) tau, was calculated
between the relative ranks for those persons in common to
both of a informant's recalls. These coefficients were .58
for informant 9 and .02 for informant 13. The lack of
concordance between the serial positions of persons in the
first and second interviews for informant 13 demonstrates
the possible difference in influence of cohort distance on
serial order between the two interviews for this informant
(from weak in the first to moderate in the second).

Discussion

Informants' recall of persons' names in this
contemporary, socially bounded community was highly
structured in terms of associative, frequency, and serial
order patterns. Individual informants shared a common
structure in the recall of fellow students. For each type

of pattern, the cohort structure of the students played the central role in the organization of recall. Informants recalled persons by cohort, typically beginning with their own, and then moving to cohorts that were progressively more distant (in terms of years) from themselves. Persons in cohorts that were distant from the informant were less likely to be recalled than persons in cohorts close to the informant.

In several ways, these results are similar to findings in research on the recall of lexical items. The strong associative patterning in informants' recall orders was also exhibited in the temporal characteristics of their recalls. The IRTs between adjacently named persons were shorter for within-cohort pairs of persons than between-cohort pairs of persons, which is congruent with results on IRTs in the recall of mixed category lists of words (Hoermann & Osterkamp, 1965; Kellas, Aschcraft, Johnson, & Needham, 1973; Mandler, 1970; Patterson, Meltzer, & Mandler, 1971; Pollio, Richards, & Lucas, 1969), words from homogeneous semantic domains (Gruenewald & Lockhead, 1980), and students' recalls of their professors by academic discipline (Rubin & Olson, 1980).

Over the course of their graduate studies, informants tended to have interacted most with those persons in their own cohort, next most with persons in cohorts chronologically close to their own, and least with persons

in distant cohorts. The frequency pattern observed here mirrors these interaction patterns, which resembles findings in research on the recall of lexical items. Mervis, Catlin, and Rosch (1976) demonstrated that when informants are asked to free list lexical items in a semantic domain, those words that are more frequently recalled are also items that are more typical, in the sense that they are judged as better examples of that domain than words less frequently recalled. Similarly, those items that are more frequently recalled are also more quickly judged as members of a given domain than less frequently recalled items (Loftus, 1973; Wilkins, 1971). In previous studies on the recall of persons' names, those persons with whom informants had strongest ties/intense interaction (Bahrick, et al., 1975; Riegel, 1973; Sudman, 1988) or who were most visible (Freeman, et al., 1987) were most likely to be recalled (Sudman, 1985, is an exception, however). These findings, together with the results in this paper, might possibly indicate a frequency - typicality relationship in the recall of persons' names, where typicality represents the degree to which persons are most closely identified, <u>from the perspective of an individual informant</u>, with the community in question.

The fact that the cohort structure underlay both frequency and serial order patterns was in accordance with research on the recall of lexical items. Several investigators have found that in free listing tasks within a

semantic domain that there is a fairly close correspondence between frequency of mention and output serial position in recall, with frequently listed words tending to be mentioned early in recall (Battig & Montague, 1969; Bousfield & Barclay, 1950; Romney & D'Andrade, 1964). Hence, serial order and frequency patterns in free recall might just be different ways of measuring the same basic concept of a lexical item's or person's cognitive salience. At least in the present study, though, the salience of a person varied across informants as a function of the informant's position in the cohort structure.

Not only were persons in cohorts distant from a informant less likely to be recalled, those persons from distant cohorts who were recalled by a informant also were less likely to be clustered by cohort. These results suggest that informants' knowledge of persons and their cohort memberships decreased with increasing cohort distance. Similarly, Freeman and Webster (n.d.) showed that in two contemporary, socially bounded communities (one recreational and the other residential), individuals have more detailed and structured knowledge of the patterns of social ties for persons who are socially close to themselves than for persons who are socially distant. They found that people perceived socially distant subgroups as relatively homogeneous and undifferentiated in terms of affiliation patterns, just as in this study persons in distant cohorts

were lumped together in recall as relatively senior or junior students, sometimes blurring differences in cohort membership.

As a concept, the cohort in this program had components of social interaction, individual traits, and formal organizational structure. During the early stages of study in the program, the cohort was a key focus of social interaction both inside and outside of classes, and continued to be a factor in shaping social interaction patterns among students in later stages of the program. Cohort membership was also a general indicator to students and others in the program of a student's progress in the program, and thus her/his academic status, work schedule, and activities. Moreover, the cohort structure was the program's official way of organizing and classifying students. With the available data, it is not possible to determine which of these three aspects of the cohort structure is most critical or operative in organizing persons in memory. In any case, it is apparent that this study does not support Bond and Brockett's (1987) notion that persons within a social context are organized in memory according to personality characteristics.

Recent research suggests that names of persons are neuropsychologically distinct from lexical labels. There have been reports of aphasic patients whose ability to retrieve acquaintances, relatives, and/or famous persons'

names (in contrast to lexical items from semantic domains and generic first names such as Mary and Bill) was selectively preserved or impaired (McKenna & Warrington, 1980; Semenza & Zettin, 1988, 1989; Warrington & McCarthy, 1987). In addition, names of persons who are/were personally known to informants appear to be distinguishable from episodic autobiographical information and non-autobiographical semantic information, as shown by patterns of total output frequencies in free recall tasks (Dritschel, Williams, Baddeley, & Nimmo-Smith, 1992). Such findings provide additional impetus for understanding how the memory of persons is organized. Further research on the recall of persons' names in contemporary, socially bounded communities, varying in composition, function, and structure and including developmental and cross-cultural studies, will help clarify what is unique about the recall of persons in this community and determine what general properties there are in the recall of persons.

NOTES

1. Organization in the recall of famous persons has also been studied (Robertson, 1990; Robertson & Ellis, 1987; Roediger & Crowder, 1976; Riegel, 1973), but this research will not be discussed here because the persons recalled in these studies were not personally known to the subjects or connected to the subjects by common community membership.

2. Responses to relation-specific person recall tasks also may exhibit serial order patterns. In response to a question in the General Social Survey regarding persons with whom respondents discuss important matters, persons tended to be mentioned in order of decreasing strength of relationship and frequency of contact (Burt, 1986).

3. In pre-testing these elicitation procedures with people from other contemporary, socially bounded communities, I found that they usually would stop halfway through their recall to ask if they should mention their own name. Since this issue disrupted the process of their recall, I believed it was best to instruct informants not to recall their own name.

CHAPTER 2

PATTERNS IN THE RECALL OF PERSONS

IN A RELIGIOUS COMMUNITY

Much attention in recent years has been given to how
people remember and think about the social relations among
persons in socially bounded communities (e.g., Bernard &
Killworth, 1977; Bernard, Killworth, & Sailer, 1979/80,
1982; Boster, Johnson, & Weller, 1987; Burt & Bittner, 1981;
Freeman, 1992; Freeman, Freeman, & Michaelson, 1988, 1989;
Freeman, Romney, & Freeman, 1987; Killworth & Bernard, 1976;
Romney & Faust, 1982; Romney & Weller, 1984). The present
paper shares with this line of research the same general
concern with the relationships between cognition and social
structure, but shifts the focus to the social structural
influences on how people remember and think about persons.

Cognitive psychology has made considerable advances in
the understanding of how lexical items are organized in
memory (for an introduction to the subject, see Puff, 1979).
By studying the way in which people list words in free
recall, psychologists have demonstrated repeatedly that
semantic similarity is the primary factor in the
organization of lexical items in memory. However, there has
been much less work done on the organization of persons in
memory, especially regarding real persons in natural
contexts. The multifaceted nature of persons in the real

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world poses a challenge for researchers to identify the main component(s) of their organization in memory.

There are at least three conceptually distinct types of response patterning that can be observed in free recall: association, frequency, and serial order. Associative patterns refer to the connections or relationships between adjacently recalled persons (or lexical items, etc.). By noticing how a subject associates from one person to the next in free recall, that subject's underlying cognitive structure of those persons may be described. Frequency patterns refer to which particular persons or types of persons are recalled. Persons recalled by a subject are naturally more salient in that subject's mind than those persons not recalled. Serial order patterns refer to which particular persons or types of persons are remembered earlier or later in recall. Persons' output serial positions in recall also index their salience (with persons mentioned earlier considered more salient), and may reflect a subject's particular orientation or bias towards searching the cognitive structure of those persons.

Brewer (1993) reviewed relevant research on the memory of persons in natural contexts. This research suggests there are at least four possible general structures that could underlie associative patterns in the recall of persons' names: social relational structures (such as kinship or social interaction), persons' individual

characteristics (such as gender, ethnicity/race, or personality), persons' spatial/geographic location, and the alphabetic/acoustic similarity of persons' names. Previous work also indicates that frequency patterns seem to be related to the intensity of social ties between the subject and persons recalled and persons' visibility in a community. Although there is little direct evidence, the same factors appear to be involved in serial order patterns in the recall of persons.

Perhaps the most extensive research on the patterns in the recall of persons has focused on the recall of acquaintances, or all persons known to a subject (Bond & Brockett, 1987; Bond, Jones, & Weintraub, 1985; Fiske, n.d.; Riegel, 1973). The major finding from this work is that subjects' associative patterns reflect the multiple social contexts (or communities) in which subjects are involved. That is, when subjects free list acquaintances, they tend to cluster, or mention successively, persons from the same social context (e.g., family, work, school, church, etc.). This demonstrates quite clearly that, at a very general level, persons are organized in memory according to social structural principles.

The study of the recall of persons in socially bounded communities allows examination of more detailed social structural influences on memory organization and permits investigation of whether individuals in such communities

share a cognitive structure of community members. Brewer
(1993) reported an analysis of the three types of response
patterning in the recall of persons among students in a
graduate academic program. Subjects in that study tended to
cluster persons by cohort (year) in the program, typically
beginning with persons in their own cohort, and then moving
to cohorts that were progressively more distant (in
chronological terms) from their own. Persons that were in
cohorts chronologically distant from a subject were less
likely to be recalled than persons in cohorts
chronologically close to a subject. That study, however,
was not able to show which aspect of the program's cohort
structure--the cohort's formal organizational properties or
the tendency for social interaction patterns to parallel the
cohort structure--was more critical in organizing persons in
memory.

The study described in this paper specifically
addresses the role of perceived social interaction, among
other factors, in the organization of persons in memory. By
focusing on a socially bounded community different in
composition, function, and structure from those examined in
earlier research, this study also contributes to the
identification of general features in the organization of
person memory.

Method

Ethnographic Background

The community studied was a Christian fellowship of
Taiwanese and first generation Taiwanese-American young
adults affiliated with a church in southern California. At
the time of data collection, the fellowship had been in
existence for four years, meeting weekly. Although there
were no official records listing all fellowship members over
the four years, 105 persons (including 54 females and 51
males) were mentioned by subjects in the recall task and one
subject (a new member) was not mentioned. Less than half of
these persons were members for all four years, but over 80%
of the 105 persons had been fairly regular attenders of
fellowship meetings during the year prior to data
collection.

Fellowship meetings typically lasted between 2 1/2 and
3 hours. Meetings generally involved singing songs, playing
games, studying the Bible, listening to guest speakers,
having refreshments, and informal socializing. Two
advisors, somewhat older than fellowship members, supervised
the fellowship's activities and occasionally attended
meetings. Every year members elected seven to ten
fellowship officers, called "coworkers" by members to
emphasize the egalitarian atmosphere of the fellowship.
There was some social interaction among members outside of

fellowship meetings and no more than about a third of the members attended church services regularly.

All fellowship members were bilingual in Mandarin and English. Mandarin, however, was the primary language used in communication among fellowship members. Over 90% of the persons went by English first names, while the remainder went by first names of Chinese origin. The two fellowship advisors were almost always referred to as "brother [advisor's surname]," said in Mandarin. Twenty-four persons had the same (identical) first name as one or more other persons in the fellowship. Fifty-seven persons were related by kinship to at least one other person in the community, with kinship relations defined as three or fewer steps in a genealogical chart; most of these kin ties were siblings and cousins. Each of the two years prior to the study the fellowship printed pocket-sized directories of members' names and telephone numbers. The names in these directories were printed both in Chinese characters and English letters, but were listed in alphabetic order by members' first names.

A few months before data collection, the fellowship developed into two sections for college-aged and high school-aged members, respectively. The sections began their meetings jointly with approximately thirty minutes of singing songs, and then continued their meetings separately in different rooms of the same building. There also was

some interaction between persons in both sections during meeting breaks and outside of meetings.

Subjects

Subjects were 25 college-aged members of the fellowship, including 11 females and 14 males.

Procedure

Subjects performed two tasks: a recall task and a pile sort of persons by social proximity. All 25 subjects did the recall task, while only 11 (5 females and 6 males) did the pile sort task. For both tasks, subjects were interviewed individually by the second author (who was a member of the fellowship) usually after fellowship meetings or church services in a private room or a quiet setting out of sight and earshot of other fellowship members. For most subjects who performed both tasks, there was a two to three week interval between the recall and pile sort tasks; for a few subjects, both tasks were performed during the same interview, with the pile sort task always following the recall task. Except for the instructions immediately preceding a task, subjects were not given any prior indication about the number or specific nature of the tasks to be performed. Subjects also were asked not to discuss the study with other fellowship members until data collection was finished.

The second author gave the following instructions
orally and bilingually to subjects for the recall task:

Who are all the people involved with the [name of the
fellowship]? In giving your answers, please try to
give first and last names, or as much of the person's
name as possible. You do not need to mention your name
or my name. List aloud the names of as many people
involved in the [name of the fellowship] that you can
think of.

No instructions were given regarding the order in which
subjects were to list names. Subjects were given ten
minutes to mention persons and their responses were recorded
on audiotape.

After 20 subjects had done the recall task, the full
name (or as much as was known) of each different person
mentioned in the recall interviews was written on a separate
3" x 5" notecard in both English letters and Chinese
characters. Cards with the names of the few persons first
mentioned in the last five recall interviews were added to
the set as they became available. The instructions for the
unconstrained single pile sort by social proximity followed
in large part those used by Freeman, et al. (1988).
Subjects were first asked to separate out from the set of
randomly shuffled cards those persons whom they did not
recognize, i.e., could not match the name with a face.
Then, subjects were instructed to sort the cards into piles

of persons who tended to like, interact with, and hang
around each other, both at fellowship meetings and elsewhere
(see Weller & Romney, 1988, for other details on the single
pile sort). Subjects' responses to this task constitute
their perceptions of the social proximities among persons in
the fellowship--i.e., perceptions of the fellowship's social
network. Individuals' reports of social proximity in pile
sort tasks have been shown to be highly accurate with
respect to observed interaction patterns (Freeman, et al.,
1988; Webster, 1992). For brevity, in the remainder of the
paper perceived social proximity will be referred to simply
as "social proximity."

Results

The identification of persons mentioned by subjects was
straightforward when the subject gave both a person's first
name and surname, when there was only one person in the
fellowship with that first name (subjects usually gave at
least a person's first name), or when the subject gave clear
descriptive information in English or Mandarin about the
person (e.g., "X's little sister"). However, when a subject
mentioned only a first name that was shared by multiple
persons in the fellowship, then a person assignment was
obtained from: 1) additional descriptive information about
the person spontaneously given by the subject, 2) process of

elimination when the subject mentioned all persons with that first name and gave surnames for all of these except for one, and/or 3) differential recognition of persons with that first name in the pile sort task. There were 31 instances in which a unique person assignment could not be made with these criteria. In the six cases where the subject mentioned all persons with a certain first name, person assignment was achieved by random matching. The other 25 cases (3.3% of all person mentions) were handled by making person assignments on the basis of which person with that first name was a current attender of the college-aged section of the fellowship (determined from informal fellowship records of attendance during the two months previous to data collection).

Subjects took a mean of 2 minutes, 25 seconds to list all the persons in the fellowship that they could, and all subjects finished within 9 minutes. The mean number of persons recalled by subjects was 30.44 (s.d. = 10.56, range: 5 to 50), excluding repetitions, self-mentions, and intrusions (persons not actually in the fellowship). One subject repeated three names, three subjects repeated two names, and four subjects repeated a name. Near the end of recall, two subjects consciously and explicitly reviewed outloud (for one subject, under her breath) a few (2-4) persons already mentioned. Persons repeated in these reviews were not counted as repetitions or included in any

analysis. Three subjects mentioned themselves. Five subjects each mentioned one or more different persons not in the fellowship. Of these six total intrusions, one was the wife of a fellowship advisor, one was the pastor of the church, two were spontaneously acknowledged by the subject as an intrusions, and two persons' names could not be identified. Self-mentions and intrusions were not included in any analysis. Only one subject mentioned any person's name in Mandarin fashion, with surname being said first, followed by the Mandarin given name. One hundred five persons (54 females, 51 males) were recalled at least once.

Associative Patterns

Measurement of clustering. Clustering (or association) in recall by a given scheme or variable (such as gender or kinship) was measured by a path length statistic based on quadratic assignment independently developed by Hubert and Levin (1976) and Carroll, Romney, Farner, and Delvac (1976). This procedure first involves defining a square, symmetric matrix of hypothesized associative strengths among the items (in this case, persons' names) for a particular scheme. This matrix may be binary (as in the case of a categorical associative structure), or valued (where the associative strengths are measured on an ordinal or higher scale). In the present study, associative strength matrices contained similarities or proximities between persons (to be

described). When these matrices were binary, "1" represented common category membership and "0" otherwise.

Next, a subject's recall order of persons can be considered as a path through a graphic representation of an associative strength matrix, where there is a link between each pair of persons. The value of a particular link l_{ij} is the value of the (i, j) cell in the associative strength matrix. The number of links in a subject's path is equal to the number of persons recalled minus one. The weighted length of a subject's path is defined to be the sum of the link values for the adjacently recalled pairs of persons. Self-mentions and intrusions were not included in subjects' recall paths. When a subject's recall included repetitions, the subject's observed weighted path length was reduced by the number of repetitions times the mean link value for the total path.

Since associative strength matrices represented proximities or similarities among persons for particular schemes, an observed path length _longer_ than expected by chance indicated clustering. The expected path length is the mean path length for all possible paths among those persons recalled by a subject (i.e., for all permutations of the recall order). For a given scheme, clustering of persons in recall was specifically indexed for each subject by simulating 10,000 random paths among just the set of persons a subject recalled and noting the proportion of path

lengths that were at least as large as the subject's observed path length. These one-tailed Monte Carlo probability values thus estimate the <u>significance</u> of a subject's clustering according to a given scheme. For most clustering schemes, the distribution of all possible path lengths among the set of persons recalled by a subject was skewed to the right, therefore requiring this nonparametric approach to measuring clustering. The measurement of clustering in recall against a single scheme is referred to as zero-order clustering in this paper.

To give a perspective on the <u>magnitude</u> (as opposed to the significance) of clustering, Adjusted Ratio of Clustering (ARC) scores (Roenker, Thompson, & Brown, 1971) were computed when the associative strength matrix was binary. This measure equals $(\underline{o} - \underline{e})/(\underline{m} - \underline{e})$, where $\underline{o}$ is the observed path length, $\underline{e}$ is the expected path length, and $\underline{m}$ is the maximum possible path length. The ARC ranges between -1 and 1, and takes a value of 0 when the observed path length is equal to the expectation and a value of 1 for maximum clustering.

<u>Zero-order clustering in recall</u>. In order to investigate the influence of social proximity on associative patterns in recall, we created a social proximity associative strength matrix from the pile sort data. Following Freeman, et al. (1988) the cells in this matrix contained proportions referring to the number of subjects

who placed a pair of persons in the same social proximity
pile in the pile sort task divided by the number of subjects
who recognized both persons. The 11 subjects who performed
the pile sort task recognized a mean of 78.18 persons and
created a mean of 26.64 piles. Social proximity data were
only available for 99 of the 105 persons since a few persons
first mentioned in the last five recall interviews were
inadvertently not included in the last few pile sort
interviews. These six persons were subsequently omitted
from subjects' recall paths (a total of seven omissions)
only for analyses involving social proximity.

Subjects' recalls demonstrated a striking degree of
clustering by social proximity. The pairs of persons
recalled adjacently by a subject were much closer socially
than would expected by chance. Table 2.1 provides the
median and range of the 25 subjects' Monte Carlo social
proximity clustering probability values. All 25 subjects
clustered by social proximity more than expected by chance
and 22 clustered at $p < .05$. The p of .3380 was for a
subject (a new member) who only mentioned five persons.
Social proximity clustering was also measured for the 11
subjects who did the pile sort task by testing each of the
11 subjects' recalls against her/his own individual binary
social proximity matrix (which indicated the pairs of
persons place in the same pile). Clustering by social
proximity was still apparent but less significant. Ten of

these 11 subjects clustered by their own binary social
proximity matrix more than expected by chance (median $\underline{p}$ =
.0234, range: < .0001 to .5100). For each of the 11
subjects, the $\underline{p}$ based on the aggregated social proximity
matrix was less than or equal to the $\underline{p}$ based on the
individual subject's matrix. Aggregation thus produced a
finer and more complete social proximity measure than any
one subject's pile sort responses.

Subjects' recalls also showed significant clustering by
several other schemes, including kinship, section, gender,
first name, and first letter of first name. For each of
these schemes, we constructed binary associative strength
matrices which indicated the kinship related, same section
(high school or college), same gender, same first name, and
same first letter of first name pairs of persons,
respectively. The kinship, first name, and first letter of
first name associative strength matrices naturally were much
sparser than the section and gender associative strength
matrices.

Subjects displayed moderate clustering by kinship in
their recalls (see Table 2.1). Twenty-three of 24 subjects
(one subject did not recall any set of persons that were kin
related) clustered by kinship more than expected by chance,
and 18 subjects clustered at $\underline{p}$ < .05. The mean kinship ARC
score was .45. One subject recalled just one pair of kin,
but not adjacently, resulting in a $\underline{p}$ of 1.0.

Table 2.1. <u>Associative patterning results for different</u>

<u>clustering schemes</u>

Clustering scheme	Monte Carlo clustering $\underline{p}$ values		Mean # "free" links
	median	range	
Social proximity	<.0001	<.0001 to .3380	29.16
Social proximity controlling for first name	.0001	<.0001 to .3380	25.80
Social proximity controlling for gender	.0527	<.0001 to .5079	11.58
Social proximity controlling for first name and kinship	.0051	<.0001 to .4312	22.24
Kinship	.0066	<.0001 to 1.0	29.44
Section	.0979	.0034 to 1.0	31.53
Gender	.0774	<.0001 to .8760	29.44
Gender controlling for first name	.2498	.0085 to .8760	26.08
First name	.0006	<.0001 to .3007	29.44
First letter of first name	.0231	<.0001 to .6817	29.44
First letter controlling for first name	.3677	<.0001 to .9560	26.08

Subjects' recalls of persons also were modestly clustered by gender (see Table 2.1). Twenty-three of the 25 subjects clustered by gender more than expected by chance and 10 clustered at $p < .05$. The mean gender ARC score was .25.

Six persons were removed from section membership clustering analysis, including the two fellowship advisors, the son of one of the advisors, and three persons for whom there were no data on section membership. Of the remaining 101 persons, 74 were in the college-aged section and 27 were in the high school-aged section. Seventeen subjects recalled one or more persons in the high school-aged section. These subjects displayed modest clustering by section (see Table 2.1), as 13 of the 17 subjects clustered by section more than expected by chance and 7 subjects clustered at $p < .05$. The mean section ARC was .27.

Moreover, clustering by same first name was strong and highly significant (see Table 2.1). All of the 23 subjects who recalled two or more persons with the same first name clustered by first name more than expected by chance, and 20 clustered by first name at $p < .05$. The mean first name ARC was .76. Despite the strength and significance of same first name clustering, same first name associations accounted for a relatively small number of adjacently recalled pairs of persons (mean = 3.28, maximum = 9).

In addition, clustering by first letter of first name was moderate (see Table 2.1). Twenty-four of the 25 subjects clustered by first letter of first name more than expected by chance, and of these subjects, 16 clustered at p < .05. The mean first letter of first name ARC was .32. Two subjects' recalls were very clearly alphabetically oriented, in terms of both associative and serial order patterning, with p's < .0001 and ARC scores > .81 for first letter of first name clustering analyses. The gamma correlations (Goodman & Kruskal, 1954) for these subjects between output serial position and position in the alphabet (i.e., a = 1, b = 2, etc.) of the first letter of persons' first names were .65 and .92, respectively. Both alphabetically oriented subjects vocally prompted themselves with spoken letter cues in recalling persons' names. The following string of letters represents the first letters of the first names of persons recalled by the second alphabetically oriented subject in recall order: A, A, A, B, B, C, D, D, D, I, H, J, J, J, J, J, K, K, K, K, L, L, L, N, O, P, P, L, Q, S, S, S, S, S, T, T, T, T, W, W, W, Y, Y, M, R. The recall strategy of the two alphabetically oriented subjects may have been made possible by regular use of the fellowship's membership directory, which was alphabetically ordered by persons' first names. These two subjects, however, still clustered by social proximity more than expected by chance (p < .0001 and p = .1278).

It was not possible to determine from the foregoing analyses which clustering scheme was the most predominant in subjects' recalls. Currently there exists no index of the significance and/or strength of clustering that is comparable across clustering schemes with different scales of measurement (e.g., social proximity was measured on an interval scale while the other schemes were measured in terms of binary categorical structures). However, by examining clustering by one scheme within and between clusters of persons defined by other schemes, we can ascertain whether one clustering scheme is general, and thus likely to be the underlying cognitive structure. We postulated that social proximity was this scheme. Of the clustering schemes examined, it is theoretically the most universal, since not all socially bounded communities have kin related members or persons of different genders. Moreover, as relations, kinship and section membership would appear to be subsumed to some extent by social proximity. In addition, as described earlier, subjects displayed highly significant clustering by social proximity.

Clustering by social proximity while controlling for clustering by other schemes. We evaluated the possibility that the highly significant clustering by social proximity was attributable to other factors which might be associated with social proximity, including same first names, gender, and kinship. The association between social proximity and

each of these variables was assessed with the quadratic
assignment procedure (QAP) (Hubert & Shultz, 1975) as
implemented in ANTHROPAC (Borgatti, 1992) and UCINET
(Borgatti, Everett, & Freeman, 1992). QAP generates the
equivalent of a permutation distribution of random
rearrangements of a data matrix (here, the 99 x 99 social
proximity matrix) and tests the significance of hypotheses
about the similarity or difference between the distributions
of comparison groups. The comparison groups here were the
two sets of pairs of persons defined by the binary first
name, gender, or kinship associative strength matrix (after
omitting rows and columns for those six persons with no
social proximity data). In other words, those pairs of
persons who shared a first name, were of the same gender, or
were kin related, were compared with those pairs of persons
who did not share a first name, were of different genders,
or were not kin related, respectively. The hypotheses
tested whether same first name, same gender, and kin related
pairs of persons were socially closer to each other than
different first name, different gender, and not kin related
pairs of persons, respectively. Unless otherwise noted, all
QAP analyses reported in this paper were done with 10,000
permutations.

QAP z-scores index the difference between observed
values (in the social proximity matrix) and expected values
(from the permutation distribution) for the comparison

groups specified in each variable's associative strength
matrix. QAP proportion as large values are nonparametric,
one-tailed Monte Carlo probability values and represent the
proportion of times in the permutations that a difference
occurred between comparison groups in the hypothesized
direction at least as large as observed. Pairs of persons
with same first names were socially closer to each other
than would be expected by chance (QAP z = 3.34, proportion
as large = .004). Furthermore, same gender pairs of persons
tended to be slightly socially closer to each other than
expected by chance (QAP z = 1.00, proportion as large =
.146). Kin related pairs of persons also were socially much
closer to each other than expected by chance (QAP z = 20.15,
proportion as large < .0001).

Since each of these variables was associated with
social proximity, we carried out analyses of clustering by
social proximity while controlling for clustering by these
potentially confounding factors. If one of the categorical
schemes was the primary scheme on which subjects'
associative patterns were based, then there should be no
social proximity clustering between clusters of persons
defined by the categorical scheme. If a categorical scheme
were the primary scheme generating subjects' associative
patterns, then the associations between persons not in the
same categorical cluster should be essentially random with
respect to other schemes, including social proximity. We

elaborated the standard approach to measuring clustering which we described earlier in order to develop a novel measure of clustering by one scheme while controlling for clustering by another scheme. This new measure is a type of restricted permutation test (cf. Dow, 1985; Gale, Hubert, Tobler, & Golledge, 1983; Krackhardt, 1992/3). It indexes the significance of clustering according to one scheme, such as social proximity, in a subject's path aside from those adjacently recalled pairs of persons that conform to some other categorical scheme. To illustrate this situation, imagine that a subject recalls 9 persons (denoted by the letters A through I) in the following order: H - B - C - I - D - E - F - G - A. Suppose that persons A, B, C, and D are female and persons E, F, G, H, and I are male. The goal in this case is to determine how much clustering by social proximity exists in this recall path apart from the B - C and E - F - G adjacently recalled pairs of same gender persons.

This can be done by simulating a large sample of randomly generated paths among these 9 persons, with the following conditions. Whenever a simulated path encounters person B it must automatically go to person C next, and vice versa. Similarly, whenever a simulated path encounters person E then it must go to persons F and then G, and whenever it encounters persons G it must go to persons F and then E. Person F may only occur between persons E and G.

Otherwise, the selection of next persons in simulated paths is random and without replacement. Both observed and simulated paths are measured according to the social proximity scheme, and the same gender adjacencies (B - C or C - B and E - F - G or G - F - E) observed in the subject's path are built into every simulated path. Just as with the standard procedure described earlier, the significance of clustering by one scheme while controlling for clustering by another is indexed by the proportion of randomly generated paths as long or longer than that observed. Ten thousand paths were simulated for each subject in each control analysis reported in this paper.

Those subsequences of adjacently recalled persons which are to be controlled for in an individual subject's path (such as B - C and E - F - G above) may be called mandatory subsequences, since they (or their mirror images) must be included in every simulated path. In an individual subject's path, there may be multiple mandatory subsequences containing varying numbers of persons in a path. In a simulated path, mandatory subsequences may occur at any point and in any order (as determined randomly). Repetitions were not included in mandatory subsequences in the analyses reported here. The order of persons in mandatory subsequences is fixed because the goal of the control analysis here is only to assess social proximity clustering between clusters defined by a categorical scheme.

The analysis of social proximity clustering <u>within</u> clusters
defined by other schemes is described in the next section.

The introduction of mandatory subsequences produces, in
effect, a decrease in the degrees of freedom for the Monte
Carlo probability values, since fewer links in simulated
paths are "free" or determined randomly. In the standard
clustering framework, where there are no mandatory
subsequences, the number of "free" links is simply the
number of links in a subject's path. With the control
procedure, the number of "free" links in a subject's path is
equal to the number of links in a subject's path minus the
total number of adjacencies in all mandatory subsequences.
Thus, the number of "free" links in a subject's path gives a
relative "degrees of freedom" index. The significance of a
subject's clustering (as indexed by a Monte Carlo
probability value) may decrease somewhat after mandatory
subsequences are controlled for, even though the strength of
clustering may not have actually decreased.

Clustering by social proximity was undiminished after
controlling for clustering by same first name (i.e.,
adjacently recalled persons with the same first names in a
subject's path were mandatory subsequences) (see Table 2.1).
All 25 subjects clustered by social proximity controlling
for first name more than expected by chance and 22 clustered
at $p < .05$.

Clustering by social proximity was also still clearly evident after controlling for clustering by gender (which included clustering by same first name) (see Table 2.1). Clustering results here show the influence of social proximity among adjacently recalled persons of different genders. Twenty-three of 24 subjects (one subject's path had only 2 "free" links after controlling for same gender and therefore was not analyzed) clustered by social proximity controlling for same gender, and 12 clustered at p < .05, even after the number of "free" links had been substantially reduced by the mandatory subsequence controls.

Since kinship and same first name were the two schemes (apart from social proximity) by which subjects most strongly clustered and because both were associated with social proximity, clustering by social proximity was tested after controlling for clustering by both kinship and same first name. If a person in a subject's path was at the end of a kinship mandatory subsequence and at the beginning of a same first name mandatory subsequence (or vice versa), the two mandatory subsequences were combined into one mandatory subsequence for simulating paths. Even after clustering by both kinship and first name schemes was controlled, clustering by social proximity remained significant (see Table 2.1). All 25 subjects clustered by social proximity controlling for kinship and same first name and 16 subjects clustered at p < .05.

Although section membership was associated with social proximity (QAP z = 11.87, proportion as large < .0001), analysis of clustering by social proximity controlling for clustering by section was not attempted since the mean number of "free" links was 5.82 if section were controlled, and thus too small to obtain reliable results.

Incidentally, the clustering by gender and by first letter of first name were apparently largely driven by the marked degree of first name clustering. When clustering by first name was controlled, the significance of subjects' clustering by gender and first letter of first name decreased noticeably (see Table 2.1). (The only subjects that clustered by first letter controlling for same first name at p < .0001 were the 2 alphabetically oriented subjects).

In addition, the two alphabetically oriented subjects still displayed clustering by social proximity after controlling for their first letter clustering and alphabetical serial ordering. For each of these subjects, 10,000 simulated paths were generated by randomly reordering persons within each observed same first letter cluster (i.e., persons mentioned successively who all had the same first letter of their first names) in the subject's path. The serial ordering of same first letter clusters, though, was exactly as in the subject's observed path. A same first letter cluster might have one or multiple persons, depending

on the subject's recall. Thus, simulated paths displayed
the same degree of first letter clustering and alphabetical
serial ordering as the subject's observed path, but were
otherwise randomly generated. As with the earlier
procedures, the lengths of the simulated paths were measured
according to the social proximity matrix. This control
analysis showed that the two alphabetically oriented
subjects' recall paths were still clustered by social
proximity after controlling for first letter clustering and
alphabetical serial ordering, with p's of .0011 and .3422,
respectively.

   Clustering by social proximity within clusters defined
by other schemes. The results thus far show that social
proximity was a highly significant clustering scheme taken
alone and that social proximity remained a significant
clustering scheme between clusters of same first name, kin
related, and same gender persons. We further tested the
generality and primacy of social proximity as an associative
factor by examining the influence of social proximity within
clusters of same first name, kin related, same gender, and
same section persons. These analyses follow a similar logic
to the control analyses reported in the preceding section.
If one of the categorical schemes was the dominant scheme on
which subjects' associative patterns were based, then there
should be no social proximity clustering within clusters of
persons defined by the categorical scheme. If a categorical

scheme were the primary scheme generating subjects'
associative patterns, then the associations between persons
within the same cluster should be essentially unrelated to
other schemes, including social proximity.

Since subjects displayed overall homogeneity in the
clustering results already described, the recall data were
aggregated in order to perform this additional analysis. A
99 x 99 person by person adjacency in recall matrix was
created in which a cell represented the number of subjects
who recalled that pair of persons adjacently divided by the
number of subjects who recalled both persons. Thus this
aggregated adjacency in recall matrix was standardized in a
way analogous to the social proximity associative strength
matrix. (Rubin and Olson (1980) also used this
standardization procedure in one of their experiments). The
only difference for the adjacency in recall matrix was that
if no subject ever recalled both persons of a pair, then the
cell for that pair was coded as missing data. By doing
this, the effects of any frequency pattern (who tends to be
recalled at all) were separated from the effects of any
associative pattern (who tends to be recalled adjacently to
whom). No genuine associative pattern can be observed for
two persons that have never been both recalled by a subject.

To measure the impact of social proximity on
associative patterns within various types of clusters of
persons, the values in the adjacency matrix were correlated

with the values in corresponding cells of the social

proximity matrix for specified pairs of persons. These

correlations appear in Table 2.2. In every case, socially

close pairs of persons were more likely to be recalled

adjacently than socially distant pairs of persons. Thus,

clustering by social proximity was still very evident within

clusters of persons defined by the first name, kinship,

gender, and section schemes. While the magnitude of these

correlations may not seem very large, the adjacency matrix

was very sparse. This matrix, then, represented an

incomplete set of data on the underlying or "true"

likelihood of adjacent recall (i.e., transition

probabilities) for all pairs of persons because of the small

number of observed adjacently recalled pairs of persons

relative to the total possible number of pairs of persons.

The .50 correlation for kin-related pairs of persons

suggests that subjects clustered more by social proximity

for kin-related pairs than non-kin-related pairs. In

addition, an analysis of covariance with adjacency in recall

as the dependent variable, social proximity as the

covariate, and same name as a factor, showed that there was

a 55% greater likelihood of being recalled adjacently for

same first name pairs of persons, beyond the influence of

social proximity.

Temporal features of recall. The amounts of elapsed

time between adjacent responses in free recall, or inter-

Table 2.2. <u>Clustering by social proximity within clusters</u>
<u>of persons defined by other schemes</u>

Pearson's r between adjacency in recall and social proximity

Pairs of persons	$\underline{r}$	$\underline{n}$
Same first name	.26	17
Kinship related	.50[b]	46
Same gender (excluding same first name)	.26[b]	1647
Same section	.26[b]	2011
High school-aged section	.23[a]	142
College-aged section	.27[b]	1869
All	.22[b]	3363

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[a]$\underline{p}$ < .01   [b]$\underline{p}$ < .001

response times (IRTs), also indicate how a subject associates from one person to the next. Short IRTs signify strong connections between persons in memory, while longer IRTs signify weaker connections. The second author measured the IRTs for each individual subject by replaying the audiotape recorded recall interviews and pressing a button on a microcomputer keyboard at the instant the name of each person was mentioned. In those few cases where the subject only provided descriptive information about the person, but not the person's name, the button was pressed when the subject began to mention the descriptive information. IRTs were electronically computed and precise to one hundredth of a second. This IRT timing procedure is very similar to those used by Gruenewald and Lockhead (1980) and Patterson, Meltzer, and Mandler (1971). Within-rater reliability was very high -- the mean correlation across subjects between two IRT timing trials was .99 (range: .98 to 1.00). The IRTs from the first timing trial were used in analysis.

The temporal properties of subjects' recalls were clearly related to social proximity. IRTs for adjacently recalled pairs of persons involving intrusions, self-mentions, and persons with no social proximity data were excluded from analysis. For nearly every subject, a consistent nonlinear pattern resulted when the social proximities for the adjacently recalled pairs of persons were plotted against the IRTs for those pairs of persons.

The raw IRTs were short for adjacently recalled pairs of persons who were socially very close, and the raw IRTs gradually increased as social proximity decreased to moderate levels of social proximity. At lower levels of social proximity, however, the raw IRTs increased much more sharply.

The relationship between social proximity and IRT was best described for most subjects' recalls by taking the natural logarithm of the raw IRTs. The mean Pearsonian correlation between log transformed IRT and social proximity was -.49. (Unless otherwise noted, the mean Pearsonian correlations reported in this paper were calculated by using Fisher's (1948) z transformations and weighting by the number of observations). The cumulative Z (from Mosteller and Bush's (1954) method of aggregation) for these correlations was -12.79. The range of subjects' coefficients was from -.69 to -.18, except for the new fellowship member who recalled only 5 persons (and thus had just 4 adjacencies), with an r of .31. Six subjects' correlations were stronger than -.6. The two alphabetically oriented subjects had correlations of -.18 and -.38, respectively. For these two subjects, the relationship between log IRT and social proximity was essentially the same for same first letter of first name adjacencies (r = -.39 and -.34) and for different first letter of first name adjacencies (r = -.29 and -.43).

IRTs, in general, increased over the course of recall, as has been observed in free recall elsewhere (e.g., Bousfield & Sedgewick, 1944). The mean correlation between log transformed IRT and output serial position was .35 (range: -.03 to .91). However, social proximity and output serial position were independent factors in describing IRTs. The mean untransformed partial correlation between log transformed IRT and social proximity controlling for output serial position was -.45 (range: -.75 to .06). Likewise, the mean untransformed partial correlation between log transformed IRT and output serial position holding social proximity constant was .38 (range: -.17 to .90). The effect of social proximity on temporal patterns, then, remained throughout the course of recall.

Just as persons' same first names had an additional influence on clustering beyond the impact of social proximity, same first names also had a quickening effect on IRTs beyond the influence of social proximity and output serial position. For 21 of the 23 subjects who recalled at least one pair of same first name persons adjacently, the IRTs for same first name pairs of adjacently recalled persons were on average shorter than expected from the multiple linear regression predicting log IRT from social proximity and output serial position (p < .0001 from a sign test).

Case study. The results on associative patterns
demonstrate that social proximity was the general,
predominant associative factor in subjects' recall of
persons. The following case study of one typical subject's
recall illustrates the effect of social proximity on
associative patterning. Figure 2.1 represents the social
proximities among the 32 persons recalled by this subject
(taken from the 99 x 99 social proximity matrix) with a
maximum link hierarchical clustering (Johnson, 1967). In
the figure, the dashes at the branch ends represent persons.
The level at which persons are joined horizontally by
continuous X's reflects (though not perfectly) the degree of
their social proximity. As shown in the figure, the group
structure of the persons recalled by this subject, in terms
of social proximity, is characterized by a number of
subgroups ranging in size and cohesiveness. The numbers at
the branch ends denote the output serial positions of these
persons in this subject's recall. This subject repeated two
persons' names. There were no social proximity data for the
23rd person recalled by this subject and adjacent pairs 19 -
20, 21 - 22, and 25 - 26 were same first name pairs of
persons.

Figure 2.1. Maximum link hierarchical clustering of the
social proximities among the persons recalled by one
subject. Numbers denote the output serial positions of
persons recalled by this subject.

```
                 1
                 7                   7

         3   2 1 2 2 2 3 1   3 2 2       2   2 3 3       2 1 1 1 1 1 1 1
 Level   3 8 0 9 1 2 4 4 5 6 0 8 6 3 2 7 1 5 1 2 4 5 9 3 4 6 8 0 1 2 9
 ------  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 1.0000  . . . . . . . . . XXX . . . . . . . . XXX XXX . . . . . . . . .
 0.9090  . . . . . . . . . XXX . . . . XXX . XXX XXX . . . . . . . . . .
 0.8180  . . . . . . . . . XXX . . . XXXXX . XXX XXX . . . XXX . . . . .
 0.7270  . . . . . . . . . XXX XXX . XXXXX . XXX XXX . . . XXX . . . .
 0.6360  . . . . . . . . . XXX XXX XXXXXXX . XXX XXX . . . XXX . . . .
 0.6000  . . . . . . XXX . XXX XXX XXXXXXX . XXX XXX . . . XXX . . XXX
 0.5560  . . . . . . XXX . XXX XXX XXXXXXX . XXX XXX . XXX XXX . . XXX
 0.5450  . . . XXX . XXX . XXX XXX XXXXXXX . XXX XXX . XXX XXX . . XXX
 0.3640  . . . XXXXX XXX XXXXX XXXXXXXXXXX XXXXX XXX . XXX XXX . . XXX
 0.3000  . . . XXXXX XXX XXXXX XXXXXXXXXXX XXXXX XXX XXXXX XXX XXX XXX
 0.2730  . . XXXXXXX XXX XXXXX XXXXXXXXXXX XXXXXXXXX XXXXX XXX XXX XXX
 0.2000  . . XXXXXXXXXXX XXXXX XXXXXXXXXXX XXXXXXXXX XXXXXXXXX XXX XXX
 0.1820  . . XXXXXXXXXXX XXXXX XXXXXXXXXXXXXXXXXXXXX XXXXXXXXX XXXXXXX
 0.1000  . . XXXXXXXXXXX XXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
 0.0910  . XXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXX
 0.0000  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

This subject clustered at the $p < .0001$ level for every
test involving social proximity, except for social proximity
controlling for gender, $p = .2135$ with 9 "free" links. This
subject's recall included many prominent associations based
on social proximity. Adjacently recalled pairs of persons
tend to be joined quite high in the diagram and subsequences
of successively recalled persons tend to correspond to the
overall social proximity group structure. We describe here
a few of these associations by social proximity in
ethnographic terms. Adjacent pairs 1 - 2 and 4 - 5
represent two pairs of same gender (male and female,
respectively) very close (or even best) friends, and
adjacent pair 6 - 7 was two sisters widely viewed as
inseparable at fellowship meetings and elsewhere. The
adjacent pair 31 - 32 was a tightly linked boyfriend -
girlfriend couple.

This subject's recall also exhibited the characteristic
nonlinear pattern between adjacently recalled pairs of
persons' social proximities and IRTs. Figure 2.2 shows the
scatterplot between IRT and social proximity for the pairs
of persons recalled adjacently by this subject. The numbers
plotted in the figure represent the output serial positions
of the 33 adjacently recalled pairs of persons (only 31 of
the pairs are plotted since there were no social proximity
data for the 23rd person recalled). In a few cases, numbers
were moved very slightly to prevent their overlapping in the

figure. IRTs are very short for socially close pairs of persons, then tend to increase slightly as social proximity decreases, and tend to increase much more abruptly for lower levels of social proximity. The Pearsonian correlation between log transformed IRT and social proximity for this subject was -.48 ($\underline{p}$ <.01). The plotted curve indicates the log transformed IRT expected from social proximity. This subject's partial correlation between log IRT and social proximity controlling for output serial position was -.45.

Frequency Patterns

The frequency patterns also were shaped by social relational factors. For each of the 25 subjects, the set of persons recalled were socially closer to one another, or more concentrated in terms of social proximity, than would be expected by chance (2000 QAP permutations per subject; mean $\underline{z}$ = 6.48, cumulative $\underline{Z}$ = 32.40, 23/25 subjects' proportion as large < .0005). This same pattern occurred for all subjects when only those 68 persons in the college-aged section were considered (2000 QAP permutations per subject; mean $\underline{z}$ = 4.58, cumulative $\underline{Z}$ = 22.89, 17/25 subjects' proportion as large < .0005).

Two factors described <u>where</u> in the fellowship's social structure the persons recalled by a subject were concentrated: persons' social proximity to an individual subject and persons' "visibility" in the fellowship. One

Figure 2.2. For one subject, the relationship between
social proximity and raw IRT for the adjacently recalled
pairs of persons. Numbers denote output serial positions of
pairs.
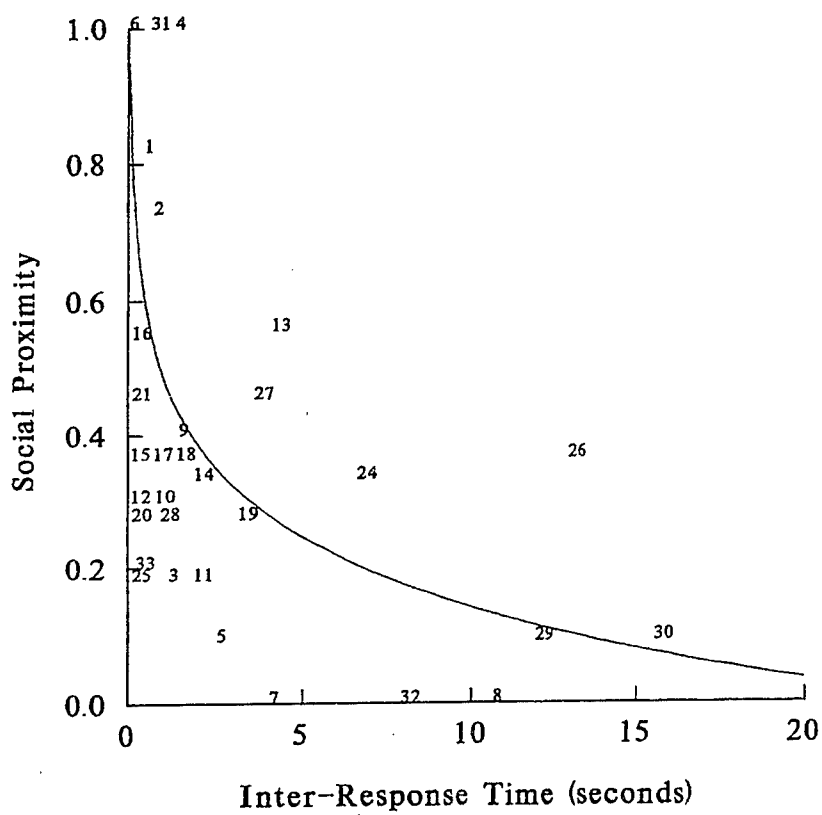
subject was never recalled and thus did not have any social
proximity data; therefore, this subject was omitted from all
subsequent analysis of frequency and serial order patterns.
For each of the 24 subjects, the persons recalled were
socially closer to the subject than those persons not
recalled (self not included in analysis), and for 14
subjects this difference was significant at $p < .001$ (mean
eta = .37, cumulative Z from individual subjects' t-scores
(Rosenthal, 1991; Winer, 1971) = 19.18). For all t-test
results reported in this paper, nonparametric Mann-Whitney
tests gave very similar results. This pattern was not due
to subjects' tendency to not recall persons in the high
school aged section. When only college-aged section persons
were considered, the effect remained for all subjects (mean
eta = .34, cumulative Z = 14.55). The proportions of
persons, averaged across subjects, recalled in the intervals
of 0, 0 - .1, .1 - .2, .2 - .3, and > .3 (lower bounds
inclusive except for 0 - .1) social proximity to the subject
were .13, .45, .44, .53, and .55, respectively. This
pattern was also evident at the individual level, with a
mean gamma correlation (Goodman & Kruskal, 1954) of .65
(range: -.2 to 1.0) between an individual subject's
proportions of persons recalled and these same intervals of
social proximity to the subject.

Persons' visibility was indirectly measured by two
structural indices: eigenvector centrality and mean social

proximity to others. Persons' eigenvector centrality scores were the loadings on the first factor of a singular value decomposition of the social proximity matrix (Bonacich, 1972). Both indices reflect the extent to which a person was viewed as socially close to other persons in general, and thus, her/his visibility in the fellowship. Freeman, et al. (1987) found that the most frequent (and thus visible) attenders of a colloquium series also were the most frequently mentioned when attenders were asked to name those persons who attended a specific colloquium. Similarly, in the fellowship, persons' overall frequency of mention by the subjects correlated moderately strongly with persons' eigenvector centrality and mean proximity scores, r = .75 and .63 (both p < .001), respectively. For each of the 24 subjects, the persons recalled by a subject had greater eigenvector centralities and mean proximities on average than those persons not recalled (self not included in analysis) (eigenvector centrality: mean eta = .48, cumulative Z = 26.53; mean proximity: mean eta = .40, cumulative Z = 21.35).

With these data, it was difficult to distinguish between the influences of social proximity to the subject and visibility on frequency patterns. The 24 subjects were socially closer to each other than expected by chance both among all 99 persons (QAP z = 9.94, proportion as large < .0001) and among those 68 persons in the college-aged

section (QAP z = 5.82, proportion as large < .0001). In addition, subjects were more frequently mentioned than those persons not interviewed (eta = .68, p < .001) and more visible (eigenvector centrality eta = .64, p < .001; mean proximity eta = .53, p < .001). These facts led to a relatively strong collinearity effect between social proximity to a subject and visibility. The mean Pearsonian correlation between social proximity to a subject and eigenvector centrality and between social proximity to a subject and mean proximity were .74 (range: .22 to .88) and .58 (range: .26 to .72), respectively.

Despite the collinearity effect, an attempt was made to see whether social proximity to the subject or visibility was more important in describing frequency patterns. For each subject, t-tests were computed which compared those persons who were and were not recalled on the residuals of the simple linear regression between eigenvector centrality and social proximity to the subject. The results were somewhat ambiguous: while only 15 of the 24 subjects' residuals were larger on average (persons' social proximities to subject greater than expected by persons' eigenvector centralities) for the set of persons recalled, the cumulative Z for the 24 subjects' t-scores was just significant at 2.15. Furthermore, 3 subjects' t-tests were significant at p < .05 in favor of social proximity to the subject, but 2 subjects' t-tests were significant at p < .05

in favor of eigenvector centrality. Hence, no firm conclusions can be formed about whether social proximity to the subject or visibility played a more crucial role in explaining the frequency patterns of subjects as a whole.

Serial Order Patterns

Just as with the frequency patterns, the serial order patterns could also be partly described in terms of persons' social proximity to the subject and their overall visibility. Nineteen of 24 subjects displayed negative Pearsonian correlations between persons' output serial position and social proximity to the subject, and the mean correlation was -.24 (range: -.53 to .20). Twenty of 24 subjects had negative correlations between persons' output serial position and eigenvector centrality (mean r = -.32, range: -.68 to .31) and 21 of 24 subjects showed negative correlations between persons' output serial position and mean proximity (mean r = -.29, range: -.60 to .34). In other words, persons that were recalled earlier tended to be socially closer to the subject and more visible than persons mentioned later in recall.

Social proximity and visibility were confounded here, too, among the sets of persons recalled by subjects. For 23 of 24 subjects, social proximity to subject and visibility were positively correlated for those persons recalled (eigenvector centrality: mean r = .66, range: -.09 to .83;

mean proximity: mean r = .57, range: -.10 to .80). In contrast with the frequency patterns, however, persons' visibility seemed to be the more influential variable in determining serial order patterns. Only thirteen of 24 subjects displayed negative partial correlation coefficients between output serial position and social proximity to subject after controlling for eigenvector centrality (range: -.50 to .45, untransformed mean partial r = -.05, cumulative Z of coefficients' t-scores = -1.33). On the other hand, the association between persons' output serial position and eigenvector centrality, holding social proximity to subject constant, remained negative for 20 of 24 subjects (range: -.57 to .47, untransformed mean partial r = -.21, cumulative Z = -5.93).

Testing an Alternative Explanation of Clustering in Recall by Social Proximity

We now consider another explanation for the associative patterning that does not rely directly on the notion of social proximity. This rival hypothesis posits that subjects' recalls were driven only by a serial order process based on persons' visibility: subjects tended to recall more visible persons in the beginning and less visible persons towards the end of recall, and any associative patterns related to social proximity might have arisen as a byproduct of this serial order pattern. If high visibility persons

tended to be recalled earlier, then it stands to reason that high visibility persons, who were socially closer to each other than expected by chance (as in the case of the subjects), would have a greater than chance likelihood of being recalled adjacently to each other (especially toward the beginning of recall). This process might then produce paths that appeared to be clustered by social proximity.

We tested this hypothesis by first simulating 30 recall paths that displayed frequency and serial order patterns similar to those observed in the subjects' observed recalls. The persons in a simulated path were selected probabilistically from the set of all 105 persons according to the proportion of subjects who recalled each person. The output serial positions of persons selected in a simulated path were also determined probabilistically according to frequency of mention (see Appendix A for a full description of the simulation process). Frequency was used for generating simulated paths for several reasons. First, overall frequency was substantially correlated with the structural measures of visibility. Second, frequency was the variable most highly correlated with persons' output serial positions in the individual subjects' recalls (mean r = -.34, range: -.68 to .31). Third, frequency had nonzero, positive values for all 105 persons (as opposed to the other visibility measures which did have zero values for a few persons).

Persons for whom there were no social proximity data were omitted from the simulated paths. The mean number of persons in the 30 simulated paths was 29.53. The mean correlation between persons' output serial position and frequency of mention in the simulated paths was -.34 (range: -.62 to -.01). Thus, the simulated paths, which were produced by a visibility-oriented serial order recall process, closely matched the subjects' observed recalls in terms of frequency and serial order patterns. These 30 simulated paths were tested for clustering by social proximity in the manner described earlier. Only 21 of the 30 paths were more clustered than expected by chance, and the median Monte Carlo p value was .3303 (range: .0081 to .8835, 6/30 paths p < .05). Obviously, then, a visibility-oriented serial order recall process cannot account for the highly significant clustering by social proximity observed in subjects' recalls. Just as high visibility persons, with their higher than expected social proximities to each other, will be more likely to be recalled adjacently to each other in such a serial order process, so too will low visibility persons, with their corresponding less than expected social proximities to each other, be more likely to be recalled adjacently to one another. This fact prevents such a serial order recall process from producing consistent clustering by social proximity.

Discussion

Subjects shared a common cognitive structure of fellowship members that was based on the fellowship's social network. Social proximity was the primary and general associative factor in subjects' recall of persons. Not only was social proximity a highly significant zero-order clustering scheme, but clustering by social proximity occurred both within and between clusters of persons defined by other schemes. Social proximity also correlated negatively with the IRTs for adjacently recalled pairs of persons. In addition, persons' same first names had an additive effect beyond social proximity on both clustering and IRTs. For some unknown reason, clustering by social proximity was more pronounced for kinship related pairs of persons than for other pairs of persons. Frequency and serial order patterns also revealed social network influences. The persons recalled by a subject tended to be socially closer to that subject and more visible (in terms of overall social proximity to others) in the fellowship than those persons not recalled. Furthermore, the most visible persons tended to be mentioned by subjects earlier in recall than less visible persons. This serial order pattern, however, did not account for the highly significant clustering by social proximity.

The negative relationship between social proximity and IRT throughout the course of recall provides strong support for the idea that the fellowship's social network served as the basis for subjects' cognitive structure of fellowship members. In previous research on the recall of persons, temporal patterns have paralleled the clustering results. Bond and associates (Bond & Brockett, 1987; Bond, et al., 1985) found that in subjects' recalls of acquaintances, IRTs were shorter within social context clusters than between social context clusters. Similarly, Brewer (1993) showed that in subjects' recalls of fellow graduate students, IRTs were shorter within cohort clusters than between cohort clusters. The logarithmic form of the social proximity - IRT relationship in the current study corresponds to Romney, Brewer, and Batchelder's (1993) prediction about the function relating IRT to semantic similarity in the free recall of lexical items from homogeneous semantic domains. Interestingly, the 2 alphabetically oriented subjects' IRTs were still negatively related to social proximity, even though these subjects apparently used a systematic recall strategy distinct from social proximity. This suggests that although various recall strategies may be used, subjects' recall processes are nonetheless influenced (or even constrained) by the organization of the underlying cognitive structure.

Subjects' clustering by persons' same names, which has been observed elsewhere (Fiske, n. d.; Fagan, 1992; Rubin & Olson, 1980), may be due to some type of inadvertent self-cuing process in which uttering (or perhaps even thinking) one person's name is very likely to bring quickly to mind another person with that same name. This effect, however, was modified in our subjects by social proximity, in that same first name pairs of persons were even more likely to be mentioned adjacently if they were socially close than if they were socially distant. This finding supplies further evidence that the social proximity structure still influenced associations that were ostensibly based on other factors.

The strong clustering by social proximity displayed by subjects in this study provides systematic confirmation of Williams and Hollan's (1981) qualitative observations of clustering by friendship, kinship, and group affiliations in high school graduates' recalls of their high school classmates. In a related study, Bjorklund and Zeman (1983) reported that when first, third, and fifth grade students recalled the names of their classmates, approximately half tended to cluster persons in terms of perceived social groupings, while other children seemingly used a variety of other clustering schemes. Further analysis of their data using techniques employed in the current study, though, is required to demonstrate clearly the relative importance of

different organizational factors in children's recall of persons.

The results from these studies and from Brewer (1993) also suggest that persons in a socially bounded community are organized in community members' memories according to the community's social structure, and not persons' personality characteristics, as Bond and Brockett (1987) have argued. Bond and Brockett (1987) showed that when recalling acquaintances, subjects clustered persons by the social context (community) in which they had interacted with persons. They also observed that _within_ clusters of persons from the same social context, subjects weakly clustered persons according to personality traits and that temporal patterns also reflected this personality subclustering. However, the similarity of persons in terms of personality traits and other individual characteristics tends to be modestly positively correlated with social proximity in socially bounded communities (Arabie, 1984; Breiger & Ennis, 1979; Iannucci, 1992). Therefore, it might be that weak clustering by personality could be observed even when subjects are actually clustering by some aspect of a community's social structure. Not only can people perceive quite accurately the global social structures of the communities in which they are involved (Cairns, Perrin, & Cairns, 1985; Freeman, et al., 1988; Webster, 1992), but perceptions of those social structures seem to dominate how

community members recall, and perhaps think about, each other. Further work, however, is required to determine definitively the relative merits of social structural and personality explanations of the organization of persons in memory.

Persons' salience in this study was partially described by both persons' visibility and social proximity to a subject. Thus, subjects' recalls reflected both community-centered and ego-centered biases in who tends to be recalled and the serial order in which persons are mentioned. These results are in accordance with previous work on frequency patterns in the recall of persons. Past research has shown that those persons who received relatively many sociometric choices from others in the community (Jennings, 1937), were most visible in the community (Freeman, et al., 1987), or with whom subjects had strongest ties/intense interaction (Bahrick, Bahrick, & Wittlinger, 1975; Brewer, 1993; Riegel, 1973; Sudman, 1988) were most likely to be recalled. Further research in other communities is required to identify the circumstances in which community- and ego-centered biases are present and to determine their relative importance in producing frequency and serial order patterns. Moreover, the general correspondence between persons' frequency of mention and output serial position in recall replicates a similar finding by Brewer (1993) and results from studies on the recall of lexical items (e.g., Bousfield

& Barclay, 1950; Noordman-Vonk, 1979; Romney & D'Andrade, 1964).

More research is needed in other socially bounded communities to determine the generality and diversity of social structural influences on the cognitive structures people use to organize persons in memory. Formal organizations with hierarchies and clearly defined social roles, for example, might provide one of many interesting comparisons to the relatively egalitarian and largely role-undifferentiated membership of the fellowship studied here.

CHAPTER 3

PATTERNS IN THE RECALL OF PERSONS IN A

DEPARTMENT OF A FORMAL ORGANIZATION

The study of human social cognition in general, and
person memory in particular, has historically relied on
experiments in laboratory settings (Fiske & Taylor, 1984;
Higgins & Bargh, 1987). Stimuli in these experiments, such
as written descriptions of fictionalized persons, have
usually focused on persons' individual traits (e.g., gender,
ethnicity/race, personality, age, attitudes, behaviors, and
interests) and typically lack social context. Consequently,
relatively little is known about the role of social
structural factors in human social cognition. Recently,
however, more attention has been paid to how individuals
remember, perceive, and think about the social relations
among persons in the social communities in which they are
involved (e.g., Bernard & Killworth, 1977; Bernard,
Killworth, & Sailer, 1979/80, 1982; Boster, Johnson, &
Weller, 1987; Burt & Bittner, 1981; Cairns, Perrin, &
Cairns, 1985; Delfosse & Smith, 1979; Freeman 1992; Freeman,
Freeman, & Michaelson, 1988, 1989; Freeman, Romney, &
Freeman, 1987; Killworth & Bernard, 1976; Marshall &
McCandless, 1957; Romney & Faust, 1982; Romney & Weller,
1984; Sluckin & Smith, 1977; Smith & Delfosse, 1978, 1980).
The research reported in this paper complements this work by

examining the social structural influences on how people remember and think about <u>persons</u> in the social communities to which they belong.

Cognitive psychology has made considerable progress in the understanding of how lexical items are organized in memory (for an introduction to the subject, see Puff, 1979). By studying the way in which people list words in free recall, psychologists have demonstrated repeatedly that semantic similarity is the primary factor in the organization of lexical items in memory. No such consensus has yet developed about how persons are organized in memory, perhaps because of the multidimensionality of persons in natural contexts and the fact that study of the topic has only recently begun.

There are at least three conceptually distinct types of response patterning that can be observed in free recall: association, frequency, and serial order. Associative patterns refer to the connections or relationships between adjacently recalled persons (or lexical items, etc.). By noticing how a subject associates from one person to the next in free recall, that subject's underlying cognitive structure of those persons may be described. Frequency patterns refer to which particular persons or types of persons are recalled. Persons recalled by a subject are naturally more salient in that subject's mind than those persons not recalled. Serial order patterns refer to which

particular persons or types of persons are remembered
earlier or later in recall. Persons' output serial
positions in recall also index their salience (with persons
mentioned earlier considered more salient), and may reflect
a subject's particular orientation or bias towards searching
the cognitive structure of those persons.

Brewer (1993) reviewed relevant research on the memory
of persons in natural contexts. This research suggests
there are at least four possible general structures that
could underlie associative patterns in the recall of
persons' names: social relational structures (such as
kinship or social interaction), persons' individual
characteristics (such as gender, ethnicity/race, or
personality), persons' spatial/geographic location, and the
alphabetic/acoustic similarity of persons' names. Previous
work also indicates that frequency patterns seem to be
related to the intensity of social ties between the subject
and persons recalled and persons' visibility in a community.
Although there is little direct evidence, the same factors
appear to be involved in serial order patterns in the recall
of persons.

Perhaps the most extensive research on the patterns in
the recall of persons has focused on the recall of
acquaintances, or all persons known to a subject (Bond &
Brockett, 1987; Bond, Jones, & Weintraub, 1885; Fiske, n.d.;
Riegel, 1973). The major finding from this work is that

subjects' associative patterns reflect the multiple social
contexts (or communities) in which subjects are involved.
That is, when subjects free list acquaintances, they tend to
cluster, or mention successively, persons from the same
social context (e.g., family, work, school, church, etc.).
This demonstrates quite clearly that, at a very general
level, persons are organized in memory according to social
structural principles.

The study of the recall of persons in socially bounded
communities allows examination of more detailed social
structural influences on memory organization and permits
investigation of whether individuals in such communities
share a cognitive structure of community members. Brewer
(1993) reported an analysis of the three types of response
patterning in the recall of persons among students in a
graduate academic program. Subjects in that study tended to
cluster persons by cohort (year) in the program, typically
beginning with persons in their own cohort, and then moving
to cohorts that were progressively more distant (in
chronological terms) from their own. Persons that were in
cohorts chronologically distant from a subject were less
likely to be recalled than persons in cohorts
chronologically close to a subject. That study, however,
was not able to show which aspect of the program's cohort
structure--the cohort's formal organizational properties or
the tendency for social interaction patterns to parallel the

cohort structure--was more critical in organizing persons in memory.

Focusing on the role of social interaction in person memory, Brewer and Yang (in press) examined the patterns in the recall of persons in a Christian fellowship of Taiwanese and Taiwanese-American young adults. They found that subjects clustered fellowship members in recall in terms of perceived social proximity, with adjacently recalled persons tending to be socially much closer than expected by chance. Persons who were more visible in the fellowship and who were socially close to an individual subject were more likely to be recalled than other persons. Similarly, subjects tended to mention higher visibility persons earlier in recall than lower visibility persons. Two subjects spontaneously attempted to recall persons in alphabetical order of their first names, yet their response patterns still revealed the impact of perceived social proximity.

This paper reports a study of the recall of persons in a community--a department of a formal organization--differing in structure, function, and composition from those studied earlier. This study provides an in-depth analysis of social structural and other factors in the recall of persons, further outlining the fundamental aspects of how persons are organized in memory. In addition, this study investigates the effects on recall patterns when subjects are instructed to recall persons in alphabetical order of

their first names. This recall task tests whether persons
are also organized in memory alphabetically and if the
influence of an underlying cognitive structure persists
under such recall constraints.

Method

Ethnographic Background

The community studied was a department within the
public affairs division of a research university in the
southwestern U.S. The two primary functions of the
department were media relations and publications. Media
relations involved the preparation of press releases and
news articles on university programs, activities, faculty,
staff, and students, and included the coordination of
contact between the media and university personnel. The
publications function comprised the production of internal
and external university publications, entailing artistic
design, photography, and printing. The campus radio station
also was under the umbrella of the department.

The department took its present organizational form
after a merger of the media relations and publications
functions, which occurred a little over two years prior to
data collection. At the time of data collection, there were
21 persons employed in the department. The department
occupied part of a floor of a multi-storied building, with

most employees' offices and cubicles located on the perimeter of this space and a few employees' cubicles located in the middle of the space. Persons who worked closely with one another tended to have offices close to each other, although this was not always the case. Two employees' offices were located elsewhere on campus.

The 21 employees included 16 females and 5 males, and no two employees shared the same first or last name. In addition to persons whose work duties were generally focused on media relations or publications, there were several administrative support employees. The organizational status hierarchy had five basic ranks. At the top of the hierarchy was the director of the department. The second level included managers (n = 5 persons) of particular department functions who reported directly to the department director. The professional and technical staff (n = 7 persons), all of whom had the word "senior" in their official job title, occupied the third level. The fourth level included the administrative support and technical assistance staff (n = 4 persons), all of whom had the work "assistant" in their official job title. Part-time student assistants and interns (n = 4 persons) held the fifth and lowest rank in the departmental status hierarchy.

In addition to normal work-related interaction, most employees in the department regularly went out to lunch with one or more of their coworkers. The department set aside

part of one afternoon a week as a snack time, during which employees in the department socialized with one another. A few employees also maintained friendships with each other outside of work.

Subjects

Subjects were thirteen employees of the department, including eleven females and two males. Eleven of the subjects were full-time employees and two were part-time student assistants. All had offices or cubicles at the department's main office location. Subjects' mean age was 35.5 years (range: 19 to 55 years) and had worked in the department for a mean of 4.4 years (range: 3 months to 11 years, 6 months). Eleven subjects were European-American, one was Korean-American, and one was Chinese-American. Individuals from each status level and main departmental function were represented in this sample.

Procedure

Ten subjects participated in two interviews, and three subjects participated in one interview in fall of 1992 (see Table 3.1). All interviews were conducted individually and privately in a vacant office in the department, except for one interview which was carried out in an office in another building on the university's campus.

The first interview (for the ten subjects who were
interviewed twice - in first row of Table 3.1) consisted of
a free recall task. I gave the following instructions
orally to subjects for the free recall task:

Who are all the people that work in the [department's

name] Department? Please list aloud the names of all

the people who work in the [department's name]

Department. You do not need to mention your name.
No instructions were given regarding the order in which
subjects were to list names and subjects were allowed as
much time as needed to mention all the persons they could.
When subjects appeared to be done or said they had listed
everyone, I prompted them once by asking if there were any
other persons in the department; in 9 of the 23 interviews,
subjects mentioned additional persons after this prompt.
Subjects' responses were recorded on audiotape. In all
interviews, subjects were not given any prior indication
about the number or specific nature of the tasks to be
performed except for the instructions immediately preceding
a task. Subjects were asked not to discuss the study with
other departmental employees until data collection was
finished.

The second interview (for those ten subjects who were
interviewed twice) occurred two to three weeks after the
first interview. The second interview began with a recall
task. Five subjects were assigned to a free recall task (as

in the first interview) and 5 were assigned to an
alphabetically directed recall task. Two subjects were
intentionally assigned to the free recall task for the
second interview (the reason for this is described in the
results section). Of the remaining 8 subjects, three were
randomly selected for the free recall task and the 5 others
were assigned to the alphabetically directed recall task.
For the alphabetically directed recall task, I gave the same
oral instructions as in the first interview, except for the
second sentence, which was replaced with: "Please list aloud
the names of all the people who work in the [department's
name] Department in alphabetical order by their first names
as best as you can."

After the recall task in the second interview, subjects
performed two quasi-successive pile sort tasks (cf. Boster,
1987; Freeman, et al., 1988). The full name (or as much as
was known) of each different person mentioned in the first
interview was written on a separate 3" x 5" notecard. (No
additional persons were mentioned in the second interview).
Subjects sorted persons for two different social relations:
how closely persons worked with one another (work proximity)
and how much persons socialized with one another
(socializing proximity). The order in which subjects
performed the pile sort tasks was balanced across subjects.
For each pile sort task, subjects were first asked to
separate out from the set of randomly shuffled cards those

persons whom they did not recognize, i.e., could not match the name with a face. For the work proximity pile sort task, subjects were instructed to:

> Sort these persons into different piles according to how much they work with each other on job-related activities. Put persons that work with one another into the same pile.

For the socializing proximity pile sort task, subjects were instructed to:

> Sort these persons into different piles according to how much they socialize with each other, such as going to lunch together, meeting outside of work after hours, and/or talking with each other about things unrelated to work or the [department's name] department. Put persons that socialize with one another into the same pile.

After the initial sort, a subject was asked to loosen her/his criterion for working together (socializing) and, if possible, join piles of persons into larger groupings on the basis of working together (socializing). This step was repeated with further loosening of the subject's criterion until the subject did not perceive larger groupings (other than the whole department as one pile). At this point, the cards were rearranged into the piles the subject made in the initial sort. Then the subject was asked to tighten her/his criterion for working together (socializing) and, if

possible, split piles of persons into smaller groupings of persons who worked (socialized) more intensely with each other. This step was repeated until the subject did not perceive finer groupings (other than each person as a single pile).

Subjects' responses to these tasks constitute their perceptions of work and socializing proximities among persons in the department -- i.e., perceptions of the department's work and socializing networks. Individuals' reports of interaction patterns in pile sort tasks have been shown to be highly accurate with respect to observed interaction patterns (Freeman, et al., 1988, 1989; Webster, 1992). For the sake of brevity, in the remainder of the paper perceived work and socializing proximity will be referred to without the modifier "perceived."

Following the pile sort tasks, each subject ranked persons in terms of how much s/he worked with them (ego rankings), and also listed each person's boss (defined as "the individual who most directly supervises and evaluates the person"). The ego ranking and boss perception tasks were given in a balanced order across subjects. The final part of the second interview entailed subjects answering demographic questions and providing information about their personal work histories in the department. The three subjects who only participated in one interview (in second row of Table 3.1) performed the free recall task and the

same set of other tasks as the subjects in the second
interview. The analysis of these subjects' recalls is
presented with the other subjects' first interview recalls.

Results

In the first interview, the 13 subjects took a mean of
59 seconds (range: 28 to 133 seconds) to name all the
persons in the department that they could. The mean number
of persons recalled by the 13 subjects was 16.0 (range: 12
to 20), excluding repetitions and self-mentions. One
subject repeated a person's name and two subjects mentioned
themselves. Self-mentions in both interviews were not
included in any analysis. There were four cases in the two
interviews where a subject did not mention a person's name
but gave a clear enough description of the person to permit
identification of that person. A total of 23 persons were
mentioned by at least one subject in the first interview.
These 23 persons included all of the 21 persons then
employed in the department and two other persons -- a
student intern no longer working in the department and
another person named by only one subject (in the pile sort
tasks, this person was recognized by only three subjects who
said this person was a student assistant).

In the second interview, alphabetically directed
subjects took a mean of 114 seconds (range: 45 to 159

Table 3.1. <u>Summary of tasks performed by subjects</u>

Subjects (n = 10) interviewed twice	first interview: - free recall of persons' names	second interview: - free recall (n = 5) or alpha- betically directed recall (n = 5) of persons' names - work and social- izing proximity pile sorts - ego rankings, boss perceptions - demographic and work history info.
Subjects (n = 3) interviewed once	- free recall of persons' names - work and socializing proximity pile sorts - ego rankings, boss perceptions - demographic and work history info.	

seconds), while free recall subjects took a mean of 28

seconds (range: 20 to 34 seconds) to list all the persons in

the department they could.   The alphabetically directed

subjects recalled a mean of 16.6 persons (range: 14 to 20)

and the free recall subjects recalled a mean of 15.6 persons

(range: 14 to 19).   There were no significant differences

between the numbers of persons recalled by subjects in the

two interviews or between the numbers of persons

alphabetically directed and free recall subjects mentioned

in the second interview.   One subject repeated one name,

another subject repeated two names, and a third subject

mentioned his own name in the second interview.   A total of

21 persons (all those employed in the department at the

time) were mentioned by at least one subject in the second

interview.   In the pile sort tasks, subjects recognized a

mean of 21.4 persons (range: 20 to 23).   In the work

proximity pile sort task subjects created a median of 6

levels of sorting (range: 3 to 17) and in the socializing

proximity pile sort task subjects used a median of 5 levels

of sorting (range: 3 to 18).

Associative Patterns

Measurement of clustering.   Clustering (or association)

in recall by a given scheme or variable (such as gender or

work proximity) was measured by a path length statistic

based on quadratic assignment independently developed by

Hubert and Levin (1976) and Carroll, Romney, Farner, and
Delvac (1976). This procedure first involves defining a
square, symmetric matrix of hypothesized associative
strengths among the items (in this case, persons' names) for
a particular scheme. This matrix may be binary (as in the
case of a categorical associative structure), or valued
(where the associative strengths are measured on an ordinal
or higher scale). In the present study, associative
strength matrices contained similarities or proximities
between persons (to be described), except where noted
otherwise. When these matrices were binary, "1" represented
common category membership and "0" otherwise.

Next, a subject's recall order of persons can be
considered as a path through a graphic representation of an
associative strength matrix, where there is a link between
each pair of persons. The value of a particular link l_{ij} is
the value of the (i, j) cell in the associative strength
matrix. The number of links in a subject's path is equal to
the number of persons recalled minus one. The weighted
length of a subject's path is defined to be the sum of the
link values for the adjacently recalled pairs of persons.
Self-mentions were not included in a subject's recall path.
When a subject's recall included repetitions, the subject's
observed weighted path length was reduced by the number of
repetitions times the mean link value for the total path.

Since associative strength matrices represented proximities or similarities among persons for particular schemes, an observed path length <u>longer</u> than expected by chance indicated clustering. The expected by chance path length is the mean path length for all possible paths among those persons recalled by a subject (i.e., for all permutations of the recall order). For a given scheme, clustering of persons in recall was specifically indexed for each subject by simulating 10,000 random paths among just the set of persons a subject recalled and noting the proportion of path lengths that were at least as large as the subject's observed path length. These one-tailed Monte Carlo probability values thus estimate the <u>significance</u> of a subject's clustering according to a given scheme. For most clustering schemes, the distribution of all possible path lengths among the set of persons recalled by a subject was skewed to the right, therefore requiring this nonparametric approach to measuring clustering. The measurement of clustering in recall against a single scheme is referred to as zero-order clustering in this paper.

To give a perspective on the <u>magnitude</u> (as opposed to the significance) of clustering, Adjusted Ratio of Clustering (ARC) scores (Roenker, Thompson, & Brown, 1971) were computed when the associative strength matrix was binary. This measure equals $(\underline{o} - \underline{e})/(\underline{m} - \underline{e})$, where $\underline{o}$ is the observed path length, $\underline{e}$ is the expected path length, and $\underline{m}$

is the maximum possible path length. The ARC ranges between -1 and 1, and takes a value of 0 when the observed path length is equal to the expectation and a value of 1 for maximum clustering.

Zero-order clustering in recall. In order to investigate the influence of work proximity on associative patterning in recall, a work proximity associative strength matrix was created from the pile sort data. For each subject, the groupings of persons sorted were ordered into levels from broadest (where the subject could not join any more piles) to narrowest (where the subject could not split any pile further). The work proximity of a pair of persons from the perspective of each subject was indexed by a proportion representing the number of levels the pair was placed in the same pile divided by the total number of levels that subject used in the task. The work proximity values for each pair of persons were averaged across all subjects who recognized both persons in that pair to arrive at an aggregated work proximity associative strength matrix. Unless otherwise noted, all work proximity values used in analysis were based on this aggregation.

Subjects' recalls in the first interview exhibited highly significant clustering by work proximity. The pairs of persons recalled adjacently by a subject worked much more closely than would be expected by chance. Table 3.2 shows the median and range of the Monte Carlo work proximity

clustering probability values for 10 subjects in the first interview. All 10 subjects clustered by work proximity at p < .02. Three subjects' recalls from the first interview were not included in this summary since their recalls were clearly locationally oriented. As revealed by their spontaneous comments and inspection of their recalls, these subjects systematically recalled persons by mentally "walking around" the perimeter and then center of the office space, listing persons as their offices were encountered. Except where otherwise noted, the first interview results reported in this paper do not include these subjects. There were no noticeable differences in the significance of work proximity clustering for the 10 subjects in the first interview when each subject's recall was tested for clustering against her/his own individual work proximity matrix (median p = .0019, range: < .0001 to .0353).

Subjects' recalls also displayed significant clustering by the socializing proximity and status schemes. An aggregated socializing proximity matrix was constructed from the pile sort data in exactly the same way as with work proximity. Clustering by socializing proximity was almost as significant as that by work proximity (see Table 3.2). All 10 subjects in the first interview clustered by socializing proximity more than expected by chance and 9 subjects clustered at p < .05, but the median p (.0072) was slightly greater than that observed for work proximity

Table 3.2. <u>Associative patterning results for different</u>

<u>clustering schemes, first interview</u>

Clustering scheme	Monte Carlo clustering p values		Number of Ss with p < .05
	median	range	
Work proximity	.0009	<.0001 to .0148	10
Work proximity controlling for status	.0605	.0002 to .5265	4
Socializ. proximity	.0072	.0003 to .0735	9
Status	.0432	<.0001 to .7285	5
Gender	.4278	.1287 to 1.0	0

<u>Note</u>. Results based on <u>n</u> = 10 subjects.

clustering (.0009). Seven of the 10 subjects clustered more
by work proximity than by socializing proximity.

To measure status clustering, a status associative
strength matrix was created which indicated the pairs of
persons holding the same status in the organizational
hierarchy. Nine of the 10 subjects in the first interview
clustered by status more than expected by chance and 5
subjects clustered at p < .05 (see Table 3.2). The mean
status ARC was .45.

Clustering by gender was measured after constructing a
gender associative strength matrix which indicated the pairs
of same gender persons. Subjects did not show any
appreciable degree of clustering by gender (see Table 3.2).
Six of the 10 subjects in the first interview clustered by
gender more than expected by chance, and no subject
clustered at p < .05.

The results for the free recall subjects in the second
interview mirrored the first interview results (see Table
3.3). As in the first interview, the recalls of 3 subjects'
were obviously locationally oriented (two of these subjects
had locationally oriented recalls in the first interview and
were intentionally assigned the free recall task for the
second interview to see if they would use the same recall
strategy; the third locationally oriented subject from the
first interview was only interviewed once). Except where

otherwise noted, the second interview results reported in
this paper do not include these subjects.

The recalls of the five alphabetically directed
subjects in the second interview also demonstrated similar
associative patterns to the free recalls of subjects in the
first interview (see Table 3.3). All 5 of these subjects
clustered more by work proximity than by socializing
proximity. Alphabetically directed subjects recalls',
though, also showed alphabetic associative influences, with
moderate clustering by first letter of first name (median p
= .1489, range: .0008 to 1.0, mean ARC = .38). Subjects'
recalls in the first interview were not characterized by
first letter of first name clustering (median p = .5326,
range: .0687 to 1.0), nor were the recalls of the 2 free
recall subjects in the second interview (both p's = 1.0).

The recalls of locationally oriented subjects in both
interviews were strongly clustered in terms of the distance
between persons' offices, as would be expected. The
shortest walking distances between each pair of person's
offices/cubicles were measured from a blueprint of the main
office location and arranged in a location distance
associative strength matrix. In the location distance
clustering analysis, persons who did not have an office in
the main office location were omitted from subjects' paths.
Also, because the location matrix contained distances
(instead of proximities), the significance of a subjects'

Table 3.3. <u>Associative patterning results for different</u>

<u>clustering schemes, second interview</u>

	Monte Carlo clustering p values		
Clustering scheme	Free recall Ss[a]	Alpha. directed Ss[b] median	range
Work proximity	<.0001, .0040	.0031	<.0001 to .5457
Work proximity controlling for status	.0130, .0269	.0270	.0016 to .6405
Socializ. proximity	<.0001, .0034	.0759	.0001 to .8079
Status	.1716, .2309	.3403	.0064 to .5751
Gender	.1119, 1.0	.3845	.1068 to 1.0

[a]$\underline{n}$ = 2 subjects. [b]$\underline{n}$ = 5 subjects.

clustering by location was assessed by the proportion of randomly generated paths as short or shorter than the observed recall path. In the first interview, the three locationally oriented subjects' location distance clustering p's were < .0001, < .0001, and .0044. The 3 locationally oriented subjects in the second interview had location distance clustering p's of < .0001, < .0001, and .0480. However, clustering by location distance was not restricted to the locationally oriented subjects. The 10 non-locationally oriented subjects in the first interview showed modest clustering by location distance (median p = .1247, range: .0005 to .2447). In the second interview, the 2 non-locationally oriented free recall subjects also displayed some clustering by location distance (p's = .0020 and .0346), as did the 5 alphabetically directed subjects (median p = .0949, range: .0113 to .7424).

It was not possible to determine from the foregoing analyses which clustering scheme was the most predominant in subjects' recalls. Currently there exists no index of the significance and/or strength of clustering that is comparable across clustering schemes with different scales of measurement (e.g., work proximity, socializing proximity, and location were measured on an interval scale while the other schemes were measured in terms of binary categorical structures). However, by examining clustering by one scheme within and between clusters of persons defined by other

schemes, one can ascertain whether a particular clustering scheme is general, and thus likely to be the underlying cognitive structure. I postulated that work proximity was this scheme. Of the clustering schemes examined, work proximity appears to be the theoretically most universal, since it represented persons' interaction patterns at work, the primary context of department members' interaction. Interaction among persons exists in every community, but not all socially bounded communities have formal statuses. In addition, as described earlier, subjects displayed highly significant clustering by work proximity.

Clustering by work proximity while controlling for status clustering. I assessed the possibility that the highly significant clustering by work proximity was due to clustering by status. In fact, pairs of persons holding the same status in the organizational hierarchy tended to work more closely with each other than expected by chance. The association between work proximity and status was assessed with the quadratic assignment procedure (QAP) (Hubert & Shultz, 1975) as implemented in ANTHROPAC (Borgatti, 1992) and UCINET (Borgatti, Everett, & Freeman, 1992). QAP generates the equivalent of a permutation distribution of random rearrangements of a data matrix (here, the aggregated work proximity matrix) and tests the significance of hypotheses about the similarity or difference between the distributions of comparison groups. The comparison groups

here were the two sets of pairs of persons defined by the
binary status associative strength matrix. The hypothesis
tested whether same status pairs of persons worked more
closely with each other than different status pairs of
persons. QAP z-scores index the difference between observed
values (in the work proximity matrix) and expected values
(from the permutation distribution) for the comparison
groups specified in binary status matrix. QAP proportion as
large values are nonparametric, one-tailed Monte Carlo
probability values and here represent the proportion of
times in 10,000 permutations that a difference occurred
between comparison groups in the hypothesized direction at
least as large as observed. The results showed that pairs
of same status persons worked more closely with each other
than would be expected by chance (QAP z = 4.53, proportion
as large = .0010).

Since status was associated with work proximity, I
measured clustering by work proximity while controlling for
clustering by status. If status was the primary scheme on
which subjects' associative patterns were based, then there
should be no work proximity clustering between clusters of
same status persons. If status were the primary scheme
generating subjects' associative patterns, then the
associations between persons not in the same status cluster
should be essentially random with respect to other schemes,
including work proximity. The standard approach to

measuring clustering described earlier was elaborated in order to measure clustering by one scheme while controlling for clustering by another scheme. (This procedure, a type of restricted permutation test [cf. Dow, 1985; Gale, Hubert, Tobler, & Golledge, 1983; Krackhardt, 1992/3], was first described by Brewer and Yang (in press)). It might be asked how much clustering according to one scheme, such as work proximity, exists in a subject's path aside from those adjacently recalled pairs of persons that conform to some other categorical scheme, such as status. To illustrate this situation, imagine that a subject recalls 9 persons (denoted by the letters A through I) in the following order: H - B - C - I - D - E - F - G - A. Suppose that persons A, B, C, and D hold one status and persons E, F, G, H, and I hold another. The goal in this case is to determine how much clustering by work proximity exists in this recall path apart from the B - C and E - F - G adjacently recalled pairs of same status persons.

This can be done by simulating a large sample of randomly generated paths among these 9 persons, with the following conditions. Whenever a simulated path encounters person B it must automatically go to person C next, and vice versa. Similarly, whenever a simulated path encounters person E then it must go to persons F and then G, and whenever it encounters person G it must go to persons F and then E. Person F may only occur between persons E and G.

Aside from these restrictions, the selection of next persons
in simulated paths is random and without replacement. Both
observed and simulated paths are measured according to the
work proximity scheme, and the same status adjacencies ($\underline{B}$ -
$\underline{C}$ or $\underline{C - B}$ and $\underline{E - F - G}$ or $\underline{G - F - E}$) observed in the
subject's path are built into every simulated path. Just as
with the standard procedure described earlier, the
significance of clustering by one scheme while controlling
for clustering by another is indexed by the proportion of
randomly generated paths as long or longer than that
observed. Ten thousand paths were simulated for each
subject in each control analysis reported in this paper.

Those subsequences of adjacently recalled persons which
are to be controlled for in an individual subject's path
(such as $\underline{B - C}$ and $\underline{E - F - G}$ above) may be called mandatory
subsequences, since they (or their mirror images) must be
included in every simulated path. In an individual
subject's path, there may be multiple mandatory subsequences
containing varying numbers of persons. In a simulated path,
mandatory subsequences may occur at any point and in any
order (as determined randomly). Repetitions were not
included in mandatory subsequences in the analyses reported
here. The order of persons in mandatory subsequences is
fixed because the goal of the control analysis here is only
to assess work proximity clustering between clusters defined
by a categorical scheme. The analysis of work proximity

clustering <u>within</u> status clusters is described in the next section.

The introduction of mandatory subsequences produces, in effect, a decrease in the degrees of freedom for the Monte Carlo probability values, since fewer links in simulated paths are "free" or determined randomly. In the standard clustering framework, where there are no mandatory subsequences, the number of "free" links is simply the number of links in a subject's path. With the control procedure, the number of "free" links in a subject's path is equal to the number of links in a subject's path minus the total number of adjacencies in all mandatory subsequences. Thus, the number of "free" links in a subject's path gives a relative "degrees of freedom" index. The significance of a subject's clustering (as indexed by a Monte Carlo probability value) may decrease somewhat after mandatory subsequences are controlled for, even though the strength of clustering may not have actually decreased.

Clustering by work proximity was essentially undiminished after controlling for clustering by status (i.e., adjacently recalled persons with the same status in a subject's path were mandatory subsequences) in subjects' first interview recalls (see Table 3.2). Nine of the 10 subjects clustered by work proximity controlling for status more than expected by chance and 4 clustered at $p < .05$. The mean number of free links was 8.5 (compared to 15.0 for

all zero-order clustering analyses), which signals a
considerable loss of degrees of freedom.

Control analyses for subjects' recalls in the second
interview yielded very similar results (see Table 3.3).
Both of the free recall subjects clustered by work proximity
after controlling for clustering by status at $p < .05$ (mean
number of free links = 9.0). Four of the 5 alphabetically
directed subjects clustered by work proximity after
controlling for clustering by status, and 3 clustered at $p <$
.05 (mean number of free links = 10.6).

Clustering by work proximity within status clusters.
The results thus far show that work proximity was a highly
significant clustering scheme taken alone and that work
proximity remained a significant clustering scheme between
clusters of same status persons. I further tested the
generality and primacy of work proximity as an associative
factor by examining the influence of work proximity within
clusters of same status persons. These analyses follow a
similar logic to the control analyses reported in the
preceding section. If status was the dominant scheme on
which subjects' associative patterns were based, then there
should be no work proximity clustering within status
clusters. If status was the primary scheme generating
subjects' associative patterns, then the associations
between persons within the same status cluster should be
essentially unrelated to work proximity.

Since subjects displayed overall homogeneity in the clustering results already described, the recall data were aggregated in order to perform this additional analysis. A 23 x 23 person by person adjacency in recall matrix was created from the 10 subjects' first interview recalls in which a cell represented the number of subjects who recalled that pair of persons adjacently divided by the number of subjects who recalled both persons. (Rubin and Olson (1980) also used this procedure for measuring adjacency in recall in one of their experiments). If no subject ever recalled both persons of a pair, then the cell for that pair was coded as missing data. By doing this, the effects of any frequency pattern (who tends to be recalled at all) were separated from the effects of any associative pattern (who tends to recalled adjacently to whom). No genuine associative pattern can be observed for two persons that have never been both recalled by a subject.

To measure the impact of work proximity on associative patterns within same status clusters of persons, the values in the adjacency matrix were correlated with the values in corresponding cells of the work proximity matrix for specified pairs of persons. For comparison, the same set of analyses was conducted replacing work proximity with socializing proximity. All sets of these correlations appear in Table 3.4. For pairs of same status persons generally and for same status pairs of particular ranks,

pairs of persons that worked more closely together were more likely to be recalled adjacently than pairs of persons who worked less closely together. Thus, clustering by work proximity was still very evident within clusters of persons defined by the status scheme. While the magnitude of these correlations may not seem very large, the adjacency matrix was very sparse. This matrix, then, represented an incomplete set of data on the underlying or "true" likelihood of adjacent recall (i.e., transition probabilities) for all pairs of persons because of the small number of observed adjacently recalled pairs of persons relative to the total possible number of pairs of persons. In addition, the influence of work proximity on associative patterning was not a byproduct of clustering by work sections. When only the 15 pairs of persons (involving 12 different persons) who held the same status and worked in the same work section (media relations, publications, administrative support) were considered, the relationship between adjacency in recall and work proximity was still clear, r = .59 (p < .05).

Moreover, for these aggregated data, subjects clustered more by work proximity within same status clusters (r = .49) than between same status clusters (i.e., different status pairs of adjacently recalled persons) (r = .19). Although there appeared to be modest zero-order clustering by location distance in subjects' free recalls, location

Table 3.4. <u>Clustering by work proximity and socializing</u>
<u>proximity within clusters of same status persons</u>

| | Pearson's r between adjacency in recall and | | | |
| | work proximity | | socializ. proximity | |
Pairs of persons	r	n	r	n
Same status	.49[b]	48	.34[a]	48
2nd status rank	.23	10	.06	10
3rd status rank	.92[b]	21	.76[b]	21
4th status rank	.62	6	.08	6
5th status rank	.10	11	.35	11
All	.40[b]	243	.35[b]	243

[a]p < .05   [b]p < .001

distance did not have an effect on associative patterns independent of work proximity clustering. Location distance and work proximity were negatively correlated for the 19 persons for whom there were location distance data (r = -.46), indicating that persons who worked closely with one another tended to have offices near each other. Once the effects of work proximity were partialled out, location distance was no longer significantly related to adjacency in recall (p > .05), as determined from a QAP multiple regression with 10,000 permutations (Krackhardt, 1987, 1988). The independent effect of work proximity on adjacency in recall, though, remained highly significant (p < .0001).

Since work proximity was clearly the dominant and general associative factor in subjects' recalls of persons, the following principal components analysis was conducted in order to display this relationship graphically. For this analysis, a 21 x 21 person by person work proximity matrix was stacked on top of a 21 x 21 person by person adjacency in recall matrix (the rows and columns for the two persons only recalled by one subject in the first interview were omitted from both of the original 23 x 23 matrices). The main diagonals for each of these submatrices were coded as missing. Next, the row - row Pearsonian correlations were computed and the first two principal components of the resulting 42 x 42 correlation matrix were extracted. These

two dimensions accounted for 87.6% of the variance in the
correlation matrix. Before plotting, the unweighted scores
on a dimension were standardized for persons in terms of
work proximity and standardized for persons in terms of
adjacency in recall. These post-standardized scores were
then multiplied by the square root of that dimension's
singular value.

Figure 3.1 depicts the common structure between work
proximity and adjacency in recall by projecting both
configurations of persons (i.e., both sets of post-
standardized and weighted scores on the first two
dimensions) into the same space. In the figure, circles
represent persons in terms of work proximity and triangles
represent persons in terms of adjacency in recall. Persons
(as circles) who are closer to each other in the figure were
judged by subjects to work more with each other than persons
who are farther apart. Persons (as triangles) who are
closer to each other were recalled more frequently
adjacently than persons who are farther apart. Lines
connect each person's position for work proximity to her/his
position for adjacency. These lines tend to be short,
illustrating the underlying similarity between work
proximity and adjacency in recall. Persons in the left half
of the figure were responsible for the department's media
relations effort, while persons in the lower right quadrant

were involved with publications. Persons in the upper right
quadrant were generally administrative support staff.

Temporal features of recall. The amounts of elapsed
time between adjacent responses in recall, or inter-response
times (IRTs), also indicate how a subject associates from
one person to the next. In cognitive psychology, it is
generally assumed that IRTs reflect the strength of the
connections in memory between successively recalled items.
Thus, short IRTs here signify strong connections between
persons in memory, while longer IRTs signify weaker
connections. I measured the IRTs for each individual
subject's recall in both interviews by replaying the
audiotape-recorded recall interviews and pressing a button
on a microcomputer keyboard at the instant the name of each
person was mentioned. In those few cases where the subject
only provided descriptive information about the persons, but
not the person's name, the button was pressed when the
subject began to mention the descriptive information. IRTs
were electronically computed and precise to one hundredth of
a second. The IRT procedure is the same used by Brewer and
Yang (in press) and is very similar to those used by
Gruenewald and Lockhead (1980) and Patterson, Meltzer, and
Mandler (1971). Within-rater reliability was very high --
the Pearsonian correlation between two IRT timing trials for
a subject's recall was always > .99. The IRTs from the
first timing trial were used in analysis.

Figure 3.1. Two-dimensional principal components analysis
representation of persons in terms of work proximity
(circles) and adjacency in recall (triangles) from
aggregated data.
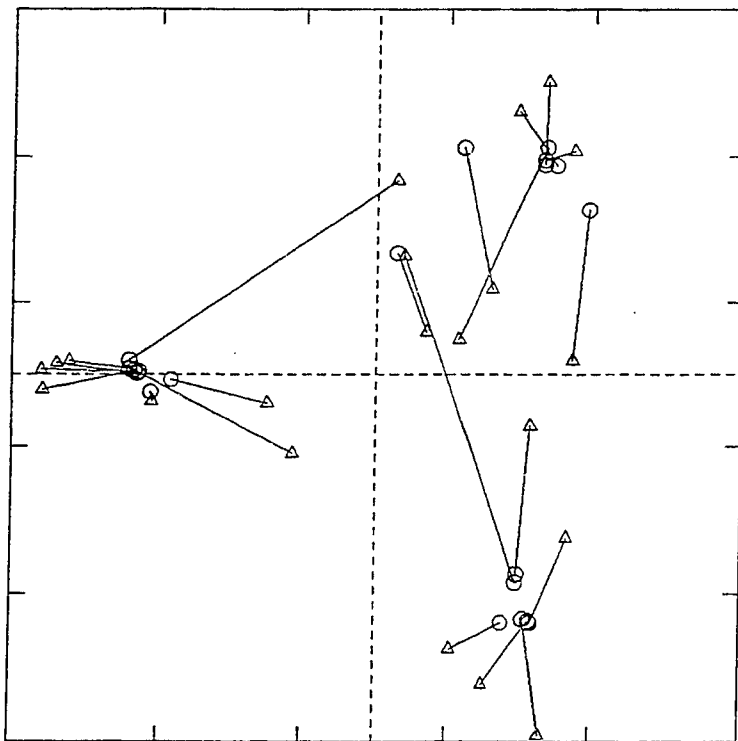
IRTs for adjacently recalled pairs of persons involving self-mentions were excluded from analysis. During the interviews, there were also a few cases in which after a subject said s/he was done recalling persons, I stopped the audiotape recorder and then restarted it a few seconds later as the subject wanted to mention another person or two. IRTs involving persons mentioned after the tape was stopped and restarted were not included in any IRT analysis.

The temporal characteristics of subjects' recalls were substantially related to work proximity. For nearly all of the 10 subjects in the first interview, a consistent nonlinear pattern appeared when the work proximities for the adjacently recalled pairs of persons were plotted against the IRTs for those pairs of persons. The raw IRTs were short for adjacently recalled pairs of persons who worked very closely together, and the raw IRTs gradually increased as work proximity decreased to moderate levels of work proximity. At lower levels of work proximity, however, the raw IRTs increased much more abruptly.

The relationship between work proximity and IRT was best described for most subjects' recalls by taking the natural logarithm of the raw IRTs. For the first interview subjects' recalls, the mean Pearsonian correlation between log transformed IRT and work proximity was -.63 and the mean Pearsonian correlation between log IRT and socializing proximity was -.56 (see Table 3.5). (Unless otherwise

noted, the mean Pearsonian correlations reported in this paper were calculated by using Fisher's (1948) z transformations and weighting by the number of observations). The cumulative Z score (based on the transformed correlations and Stouffer's method of aggregation (Mosteller & Bush, 1954)) for the log IRT x work proximity correlations was -7.97.

IRTs, in general, increased over the course of recall, as has been observed in free recall elsewhere (e.g., Bousfield & Sedgewick, 1944; Brewer & Yang, in press). The mean Pearsonian correlation between log IRT and the output serial position for adjacently recalled pairs of persons for the 10 subjects' first interview recalls was .56 (range: .16 to .90). However, work proximity and output serial position were independent factors in describing IRTs. The mean untransformed partial correlation between log IRT and work proximity controlling for output serial position was -.58 for the 10 subjects' first interview recalls (see Table 3.5). Similarly, the mean untransformed partial correlation between log IRT and output serial position holding work proximity constant was .44 (range: -.06 to .92). The effect of work proximity on temporal patterns, then, persisted throughout the course of recall.

Just as persons' same status had an amplifying effect on clustering by work proximity, same status also had a accelerating influence on IRTs beyond the impact of work

Table 3.5. <u>Temporal patterns for adjacently recalled pairs</u>

<u>of persons</u>

Subjects' recalls	$\underline{r}$ log IRT x work prox.	partial $\underline{r}$ log IRT x work prox.|output serial position
First interview[a]		
mean	-.63	-.58
range	-.88 to -.18	-.88 to -.04
Second interview		
free recall Ss[b]	-.47, -.51	-.35, -.51
alpha. dir. Ss[c]		
mean	-.26	-.29
range	-.54 to -.04	-.44 to -.09

[a]$\underline{n}$ = 10 subjects   [b]$\underline{n}$ = 2 subjects   [c]$\underline{n}$ = 5 subjects

proximity and output serial position. In 8 of the 10 first interview subjects' recalls the log IRTs for same status pairs of adjacently recalled persons were quicker, on average, than expected from the multiple linear regression predicting log IRT from work proximity and output serial position ($\underline{p}$ = .11 from a sign test).

The recalls of subjects in the second interview exhibited temporal patterns paralleling those observed in the first interview, although alphabetically directed subjects' results were somewhat weaker (see Table 3.5). For both of the free recall subjects and 4 of the 5 alphabetically directed subjects, the mean log IRT was shorter for same status pairs of adjacently recalled persons than expected from the multiple linear regression predicting log IRT from work proximity and output serial position.

Furthermore, the temporal patterns of the locationally oriented subjects' recalls also appeared to be influenced by work proximity. The partial correlations between log IRT and work proximity controlling for location distance for the 3 locationally oriented subjects in the first interview were -.53, -.59, and .41 (mean = -.24), and in the second interview were -.32, -.29, and -.04 (mean = -.22). When both location distance and output serial position were held constant, these values did not noticeably change (first interview mean = -.22, second interview mean = -.23). If each locationally oriented subject's recall in each

interview were considered to be independent of each other (4 subjects were responsible for 6 locationally oriented recalls), then the 6 second-order partial correlations would be nearly significant as a set, with a cumulative Z of -1.82 from aggregating the coefficients' t-scores (Winer, 1971; Rosenthal, 1991).

Case study. The results on associative patterns demonstrate that work proximity was the general and principal associative factor in subjects' recall of persons. The following case study of one typical subject's recall portrays the effect of work proximity on associative patterning. Figure 3.1 represents the work proximities among the 18 persons recalled by this subject (taken from the 23 x 23 work proximity matrix) with a maximum link hierarchical clustering (Johnson, 1967). In the figure, the dashes at the branch ends represent persons. The level at which persons are joined horizontally by continuous X's reflects (though not perfectly) the degree of their work proximity. The three main subdivisions/work sections of the department can be seen fairly clearly. The numbers at the branch ends denote the output serial positions of these persons in this subject's recall.

This subject clustered at p = .0007 for work proximity, p = .0003 for status, and p = .2241 for work proximity controlling for status (with 7 "free" links). Adjacently recalled pairs of persons tend to be joined high in the

diagram and subsequences of successively recalled persons
tend to correspond to the overall work proximity group
structure.

This subject's recall also displayed the characteristic
nonlinear pattern between adjacently recalled pairs of
persons' work proximities and IRTs. Figure 3.2 shows the
scatterplot between IRT and work proximity for the pairs of
persons recalled adjacently by this subject. The numbers
plotted in the figure represent the output serial positions
of the 17 adjacently recalled pairs of persons. IRTs are
very short for pairs of persons that work closely with each
other, then tend to increase slightly as work proximity
decreases, and tend to increase much more sharply for lower
levels of work proximity. The Pearsonian correlation
between log transformed IRT and work proximity for this
subject was -.62. The plotted curve indicates the log IRT
expected from work proximity. This subject's partial
correlation between log IRT and work proximity controlling
for output serial position was -.69.

Frequency patterns

As already noted, each subject recalled a large
proportion of persons in the department in each interview.
In both interviews, the director of the department recalled
all persons then employed in the department. No other
subject recalled all persons then employed in any interview.

Figure 3.2. Maximum link hierarchical clustering of the
work proximities among the persons recalled by one subject.
Numbers denote the output serial positions of persons.

```
          1 1 1 1                 1     1     1 1 1
Level     8 2 3 1 9 3 1 5 6 4 2   0 8   6 7   4 5 7
-----     - - - - - - - - - - -   - -   - -   - - -
1.000     . . . . . . . . . . .   . .   . .   . XXX
0.942     . . . . . . . . . . .   . .   . .   . XXXXX
0.902     . . . . . . . . XXX .   . .   . .   . XXXXX
0.897     . . . . . . . . XXX .   . .   . XXXXXXX
0.868     . . . . . . . XXXXX .   . .   . XXXXXXX
0.860     . . . XXX . . XXXXX .   . .   . XXXXXXX
0.819     . XXX XXX . . XXXXX .   . .   . XXXXXXX
0.816     . XXX XXX . . XXXXXXX   . .   . XXXXXXX
0.677     . XXXXXXX . . XXXXXXX   . .   . XXXXXXX
0.567     . XXXXXXX . . XXXXXXX   . .   XXXXXXXXXX
0.482     . XXXXXXX XXX XXXXXXX   . .   XXXXXXXXXX
0.428     XXXXXXXXX XXX XXXXXXX   . .   XXXXXXXXXX
0.384     XXXXXXXXX XXX XXXXXXX   XXX   XXXXXXXXXX
0.353     XXXXXXXXX XXXXXXXXXXX   XXX   XXXXXXXXXX
0.286     XXXXXXXXX XXXXXXXXXXXXX XXXXXXXXXXXXXXXX
0.134     XXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0.073     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

Figure 3.3. For one subject, the relationship between work proximity and raw IRT for the adjacently recalled pairs of persons. Numbers denote output serial positions of pairs.
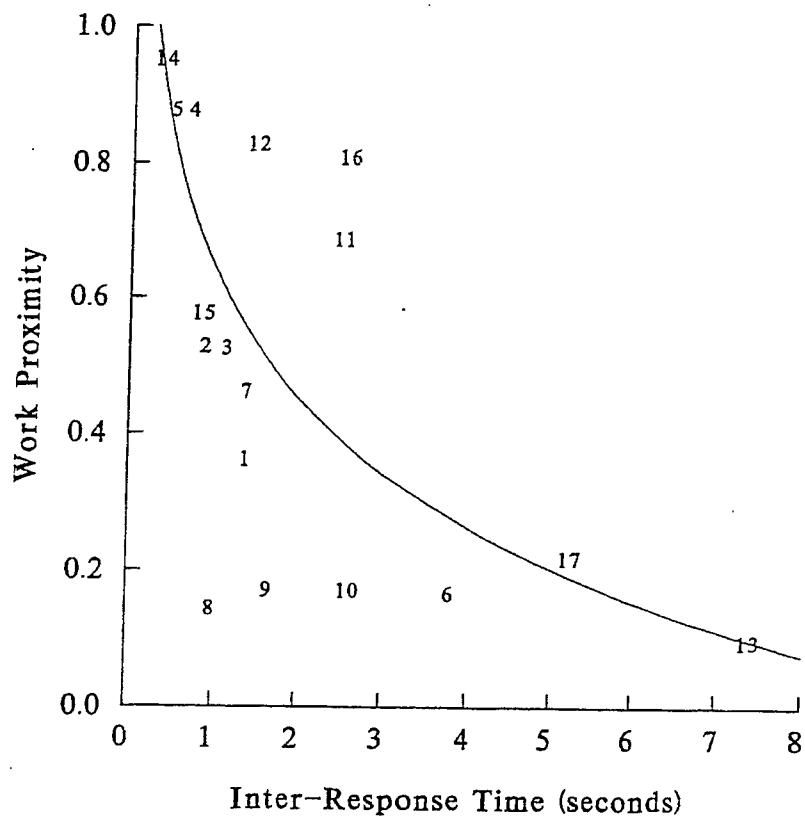
Since there were no other indications that individual
subjects had fundamentally different frequency patterns from
each other, frequency patterns are discussed here in terms
of persons' overall frequency of mention (based on all the
recalls of all subjects, including the locationally oriented
subjects). Because subjects recalled most persons in the
department, the focus here will be on those persons not
mentioned by every subject in both interviews. The four
persons recalled least often were: the two persons recalled
once in the first interview (described earlier), a manager
whose office was in another building and who had the lowest
mean work proximity to others (recalled once in the first
interview and twice in the second), and a part-time student
assistant who also worked outside of the department's main
office location (mentioned twice in the first interview and
once in the second).

Of the remaining persons who were not mentioned by
every subject, three were part-time students assistants
(mentioned by 3 to 6 subjects in the first interview and by
6 to 8 subjects in the second), one was a managerial level
employee that had just recently joined the department
(recalled by 4 subjects in the first interview and by 5
subjects in the second), and another was a senior
professional staff person who was on temporary leave
(mentioned by 7 subjects in the first interview and by 8
subjects in the second). There were 6 other persons not

mentioned by one or two subjects in the first interview and 4 persons not mentioned by one or two subjects in the second interview. These non-mentions were not patterned in any obvious way. Thus, the persons most likely recalled were simply the most visible in terms of regular physical presence--i.e., those who had an office in the main office location, were full-time employees, were currently working, and had been employed in the department for more than a short period of time.

The ten subjects who were interviewed twice exhibited relatively high test-retest reliability in the persons recalled in both interviews. For each subject, a Jaccard coefficient (intersection/union of two sets) was computed for the sets of persons recalled in the two interviews. The mean coefficient was .83 (range: .68 to 1.00).

Serial order patterns

The serial ordering in subjects' recalls was noticeably related to social structural variables, namely persons' status in the organizational hierarchy and persons' work proximity to the subject. The influence of status was most distinctly shown by the fact that the director of the department was named first by 6 of the 10 subjects in the first interview and by both free recall subjects in the second interview. Eight of the 10 subjects in the first interview had positive gamma correlations (Goodman &

Kruskal, 1954) between persons' output serial position and status rank (mean = .43, range: -.12 to .76; mean r = .52, Z = 6.47). In other words, persons of higher status tended to be recalled earlier than persons of lower status. Status also impacted the serial order patterns in the 2 free recall subjects' recalls in the second interview, with gammas of .10 and .41.

Subjects also tended to mention persons that they worked with more closely earlier in recall than persons they worked with less closely. Two measures of a person's work proximity to a subject were available: subjects' responses in the ego ranking task and the work proximities from the work proximity associative strength matrix (based on the pile sort data). The following results are based on the former measure since they fit the observed serial patterns slightly better. Nine of the 10 subjects in the first interview displayed positive gamma correlations between persons' output serial position and work proximity to the subject (mean = .26, range: -.05 to .63; mean r = .41, Z = 4.82). The recalls of the 2 free recall subjects in the second interview showed a similar relationship, with gammas of .25 and .16. (In addition, the serial ordering in these two subjects' recalls was fairly similar across interviews. For each of these subjects, the gamma correlations (which are also Kendall's taus in this case) between persons' output serial positions (ranked) for the persons recalled in

both interviews were .54 ($\underline{r}$ = .70) and .39 ($\underline{r}$ = .56),
respectively).

Status, though, was modestly more influential than work
proximity to a subject in determining serial order patterns.
For 7 of the 10 subjects in the first interview, the status
serial order gammas were larger than the work proximity
serial order gammas. In addition, the mean partial
correlation between output serial position and status
holding work proximity to a subject constant was .41 (range
= -.17 to .72; $\underline{Z}$ = 5.47), which was greater than the mean
partial correlation between output serial position and work
proximity to a subject controlling for status, mean = .30
(range: -.17 to .61; $\underline{Z}$ = 3.64).

The alphabetically directed subjects in the second
interview demonstrated comparable serial order results,
although somewhat less in magnitude. All 5 subjects had
positive status serial order gammas (mean = .28, range: .08
to .42; mean $\underline{r}$ = .34, $\underline{Z}$ = 2.98) and 4 of the 5 subjects had
positive work proximity serial order gammas (mean = .19,
range: -.04 to .40; mean $\underline{r}$ = .26, $\underline{Z}$ = 2.26). The recalls of
the alphabetically directed subjects, however, also showed
an alphabetical serial ordering effect that free recall
subjects in the first interview did not. All 5
alphabetically directed subjects had positive gammas between
persons' output serial position and position in the alphabet
of the first letter of persons' first names (ranked for the

persons recalled by a subject) (mean = .28, range: .06 to
.57; mean r = .37, Z = 3.17). In contrast, the mean
alphabetical serial order gamma for the 10 subjects in the
first interview was -.02 (range: -.37 to .10). The status
serial ordering in alphabetically directed subjects' recalls
was not due the alphabetical serial ordering: the mean
partial correlation between persons' output serial position
and status controlling for position in the alphabet for the
first letter of persons' first names was .26 (range: .11 to
.48; Z = 2.11). Incidentally, all 3 locationally oriented
subjects in the first interview and 2 of the 3 locationally
oriented subjects in the second started their recalls by
beginning their mental walks around the perimeter of
department's main office location from the vacant office
where the interview took place.

Testing serial order explanations of associative patterning

I now consider other explanations for the associative
patterning that do not rely directly on the concept of work
proximity. The first rival hypothesis posits that free
recall subjects' recalls were driven only (or largely so) by
a serial order process based on persons' status, since
status was the primary factor involved in subjects' serial
order patterns. If subjects tended to recall higher status
persons in the beginning and lower status persons towards
the end of recall, then any associative patterns related to

work proximity might have arisen as a byproduct of this serial order pattern.

I tested this hypothesis by first simulating 30 recall paths that displayed frequency and serial order patterns similar to those observed in the subjects' observed recalls from the first interview. The persons in a simulated path were selected probabilistically from the set of all 23 persons according to the proportion of subjects in the first interview who recalled each person. The output serial positions of persons selected in a simulated path were determined probabilistically according to status (see Appendix B for a full description of the simulation process). The mean number of persons in the 30 simulated paths was 16.5. The mean gamma correlation between persons' output serial position and status in the simulated paths was $-.44$ (range: $-.77$ to $-.19$). Thus, the simulated paths, which were produced by a status-oriented serial order recall process, closely matched the subjects' observed recalls in terms of frequency and serial order patterns. These 30 simulated paths were tested for clustering by work proximity in the manner described earlier. Fifteen of the 30 paths were more clustered than expected by chance, and the median Monte Carlo p value was .4939 (range: .0152 to .9817, 2/30 paths $p < .05$). Obviously, then, a status-oriented serial order recall process does not contribute at all to the

highly significant clustering by work proximity observed in subjects' recalls.

The second rival hypothesis postulates that alphabetically directed subjects' recalls were driven only (or mainly so) by a serial order process based on the alphabetical order of persons' first names, since alphabetical order was a major factor involved in these subjects' serial order patterns. This hypothesis was tested in exactly the same way as the status serial ordering hypothesis (see Appendix B for additional details). The mean number of persons in the 30 simulated paths was 16.7. The mean gamma correlation between persons' output serial position and alphabetical position in the simulated paths was .28 (range: -.02 to .55). Therefore, these simulated paths, which were generated by an alphabetically-oriented serial order recall process, strongly resembled the alphabetically directed subjects' observed recalls in terms of frequency and serial order patterns. When these 30 simulated paths were tested for clustering by work proximity, only 14 of the 30 paths were more clustered than expected by chance, and the median Monte Carlo p value was .6124 (range: .0519 to .9745). Plainly, the highly significant clustering by work proximity observed in alphabetically directed subjects' recalls was not due in any way to an alphabetically-oriented serial order recall process.

Other evidence for work proximity and status as fundamental
organizational factors in recall

Subjects' spontaneous, unprompted comments about their
recalls and responses to other tasks also shed light on how
they organized persons in memory. One subject succinctly
summarized how she recalled persons at the end of an
interview: "I did it hierarchically and said [department
director's name], the director, and then went by the
groups." I asked, "What groups are those?" and she responded
"The [media relations people] . . . . the work groups." She
then pointed out that she thinks about others in the office
in terms of hierarchy and work groups. In doing the work
proximity pile sort task, another subject volunteered the
following remark which suggests that persons' work proximity
to him led to their salience in his mind: "I tend to
organize my thoughts about other people by familiarity, in
terms of how much I work with them. I think about my own
realm." Still another subject, while performing the
socializing proximity ego ranking task, indicated the
greater significance of work relations over socializing: "I
just never look at most of these people that way. It's all
work, work, work." This view was echoed by other subjects
while performing socializing proximity tasks and is
supported by the greater density of the work proximity
matrix (.26) in comparison to the socializing proximity
matrix (.14).

Moreover, in the second interview, all alphabetically directed subjects reported difficulty with the task. Also, 9 of the 13 subjects in the first interview mentioned at least one person's work section or role (e.g., media relations, publications, director, artist, student assistant, etc.) along with the person's name. Four of these subjects made extensive references to the work section/role of individual persons and/or clusters of persons in addition to giving persons' names, even though recall instructions simply asked for persons' names.

Furthermore, two subjects had one case each of misnaming a person's last name and these errors were related to social structural factors. Both misnamings involved a different boss - subordinate pair of persons who worked closely with each other. For each of these subjects, the proportion of work proximity link values among the persons recalled which were as large or larger than the work proximity link for the pair involved in the misnaming were .03 and .10, respectively. In each case, the subject who committed the misnaming error was not in the same work section as the pair of persons involved in the misnaming. Person confusion errors have previously been shown to be patterned by social relations (Fiske, in press; Fiske, Haslam, & Fiske, 1991).

Discussion

Subjects shared a common cognitive structure of persons that was based on the department's work network and status hierarchy. Work proximity was the predominant and general associative factor in subjects' recall of persons. Status also was a significant, but secondary, associative factor. The IRTs for adjacently recalled persons confirmed the influences of work proximity and status on association in recall. Subjects' frequency patterns showed that the most visible persons were the most likely recalled. In addition, higher status persons and persons with whom the subject worked more closely were named earlier in recall than lower status persons and persons with whom the subject did not work closely. The status serial order pattern, however, did not account for the highly significant clustering by work proximity.

The patterns in the recall of persons were quite stable across interviews for those subjects who were interviewed twice, as Brewer (1993) also found. Alphabetically directed subjects were only partially successful in recalling persons in alphabetical order by the first letter of persons' first names. This result and subjects' spontaneously acknowledged difficulty with the task imply that subjects did not have an alternate organization of persons in terms of an alphabetical index of their names. They did show, however,

virtually the same recall patterns as free recall subjects, although their associative and serial order results were somewhat weaker. The alphabetical serial ordering in these subjects' recalls could not explain either the clustering by work proximity or the status serial ordering. Regardless of whether an alphabetical recall strategy is imposed on subjects (as in this study) or adopted by subjects voluntarily (as with two of Brewer & Yang's (1993) subjects), subjects' recall processes still seem to be affected (or even limited) by the organization of the underlying cognitive structure.

The negative relationship between work proximity and IRT throughout the course of recall bolsters the notion that the department's work network served as the primary basis for subjects' cognitive structure of fellowship members. In previous research on the recall of persons, temporal patterns have reflected the clustering results. Bond and associates (Bond & Brockett, 1987; Bond, et al., 1985) found that in subjects' recalls of acquaintances, IRTs were shorter within social context clusters than between social context clusters. Similarly, Brewer (1993) showed that in subjects' recalls of fellow graduate students, IRTs were shorter within cohort clusters than between cohort clusters. The logarithmic form of the work proximity - IRT relationship in the current study mirrors a very similar observation by Brewer and Yang (in press). They found that

the mean Pearsonian correlation between social proximity and log IRT for adjacently recalled pairs of persons was -.49, which compares with the mean work proximity - log IRT correlation of -.63 in the present study. Both of these results correspond to Romney, Brewer, and Batchelder's (1993) predictions about the function relating IRT to semantic similarity in the free recall of lexical items from homogeneous semantic domains. Adjacently recalled pairs of persons' same status, though, still had a quickening impact on most subjects' IRTs beyond the effects of work proximity and output serial position. Moreover, even the temporal patterns in the locationally oriented subjects' recalls were influenced by work proximity, which further suggests that work proximity was the fundamental associative factor for all subjects, no matter what recall strategy they used.

This study provides additional compelling evidence for the social structural basis of the organization of persons in memory. The findings from the present study, Bjorklund and Zeman (1983), Brewer (1993), Brewer and Yang (in press), and Williams and Hollan (1981) all suggest that persons in a socially bounded community are organized in community members' memories according to the community's social structure, and not persons' personality characteristics, as Bond and Brockett (1987) have asserted. Bond and Brockett (1987) showed that when recalling acquaintances, subjects clustered persons by the social context (community) in which

they had interacted with persons. They observed that <u>within</u> clusters of persons from the same social context, subjects weakly clustered persons according to personality traits and that temporal patterns reflected this personality subclustering. However, persons' similarity in terms of personality traits and other individual characteristics tends to be modestly positively correlated with social proximity in socially bounded communities (Arabie, 1984; Breiger & Ennis, 1979; Iannucci, 1992). Therefore, it might be that weak (and spurious) clustering by personality could be observed even when subjects are actually associating by some aspect of a community's social structure. It remains for future work, however, to ascertain the relative merits of social structural and personality based explanations of the organization of persons in memory.

Persons' salience in this study was described by their visibility (for frequency patterns) and status and work proximity to the subject (for serial order patterns). Previous research has also shown that persons' visibility in a community (whether measured by regularity of physical presence or centrality of social position) is positively related to persons' frequency of mention (Brewer & Yang, in press; Freeman, et al., 1987; Jennings, 1937).

Persons' salience was further characterized by both community-centered (status) and ego-centered (work proximity to the subject) factors as revealed by the serial order

patterns. Brewer and Yang (in press) reported a result
somewhat analogous to status serial ordering. They found
that persons in the religious fellowship who were more
visible, in terms of centrality in the fellowship's social
network, tended to be recalled earlier than less visible
persons. Conceptually speaking, centrality in an
egalitarian community like the religious fellowship might be
considered a cousin of status, given the relationships
between centrality and perceived leadership in laboratory
communication networks (Freeman, Mullholland, & Roeder,
1979) and between friendship network centrality and
reputational power in formal organizations (Krackhardt,
1990). Furthermore, Brewer (1993) observed serial order
patterns that resembled the work proximity to a subject
serial ordering in this study. In that study, subjects
tended to recall persons who were in cohorts chronologically
close to themselves earlier in recall than persons in
distant cohorts. Hence, there appears to be a small set of
basic variables, including visibility, status/dominance, and
social structural proximity to a subject, which contribute
to the salience of community members in the minds of
individual community members.

Freeman (1992, p. 126) noted that ". . . all the
individuals involved in any particular community would be
expected ultimately to produce very similar mental images of
group structure in that community." The results from the

present study suggest that it is precisely this shared

cognitive representation of a community's social structure

that serves as individuals' cognitive structure of <u>persons</u>

in the community. Further research that includes

developmental and additional cross-cultural studies will

help determine the universality of these social structural

influences on person memory.

CHAPTER 4

DISCUSSION AND CONCLUSIONS

Several general findings emerge from these studies: 1)
as revealed by subjects' associative patterns, the
underlying cognitive structure of persons in a community is
based on the community's social structure; 2) as indicated
by subjects' frequency and serial order patterns, the
salience (in memory) of persons in a community is related to
a small number of variables, including proximity to a
subject in the community's social structure, visibility, and
status; and 3) patterns in the recall of persons are uniform
across subjects and subjects exhibit reliable recall
patterns over time. I discuss each of these main results in
turn.

In each of the three communities, subjects shared a
common cognitive structure of community members that was
based on the community's social structure. In the religious
fellowship and the organizational department, perceived
interaction among persons (in social and work modes,
respectively) was the critical social structural feature
which organized persons in memory. This may have also been
the case in the graduate academic program where the
program's cohort structure (which was the apparent
associative factor in subjects' recalls) paralleled

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students' interaction patterns. The associative patterns observed in all studies provide systematic confirmation of Williams and Hollan's (1981) qualitative observations of clustering by friendship, kinship, and group affiliation in high school graduates' recalls of their high school classmates. In a related study, Bjorklund and Zeman (1983) reported that when first, third, and fifth grade students recalled the names of their classmates, approximately half tended to cluster persons in terms of perceived social groupings, while other children seemingly used a variety of other clustering schemes. More detailed analysis of their data might reveal an even greater influence of social structure on associative patterns.

There are at least two possible, but not conflicting, explanations for why interaction patterns serve as the basis for the cognitive structure of persons in a socially bounded community. The first, and perhaps more obvious, is a classic associationist argument that items (persons in this case) build up associative links with each other in memory proportional to the degree of their spatiotemporal contiguity. In this view, interaction patterns are simply a gloss for persons' spatiotemporal contiguity. Persons often seen together interacting and mentioned together in everyday conversation therefore become more strongly associated in memory than persons not seen together or mentioned together

in everyday conversation (cf. Bond, Jones, & Weintraub, 1985).

A second account of the social structural basis of the organization of persons in memory suggests that the social network among persons may indeed be the most important information, in evolutionary terms, for an individual to know about fellow community members. In the animal behavior and social science literature there are countless demonstrations of the social, economic, political, psychological, physiological, and reproductive consequences of social networks/affiliation patterns in many species. In such circumstances, knowledge of these social networks/ affiliation patterns (e.g., who is friend and who is foe) offers competitive advantage over others. As a result, humans' (and other species') ability to perceive social structure accurately (documented by Cairns, et al., (1985) Cheney & Seyfarth (1990), Dasser (1988a, b), Delfosse & Smith (1979), Freeman, et al. (1988, 1989), Gouzoules, Gouzoules, & Marler (1984), Marshall & McCandless (1957), Smith & Delfosse (1978, 1980), and Webster (1992)) would be an evolutionary outcome of this selection process. However, social networks may be evolutionarily so significant that humans not only can perceive social networks accurately but that they remember, and perhaps think about, each other primarily in terms of the social networks in which they are embedded. It should be noted again, though, that the

associationist and evolutionary accounts for the social structural basis of the organization of persons in memory do not conflict with each other.

Thus, associative patterns in the recall of persons in socially bounded communities principally involve social relational structures and do not seem to correspond to persons' individual characteristics, locations, or the alphabetic/acoustic similarities of their names. Bond and Brockett (1987), however, showed that when recalling acquaintances, subjects clustered persons by the social context (community) in which they had interacted with persons. They observed that within clusters of persons from the same social context, subjects weakly clustered persons according to personality traits and that temporal patterns reflected this personality subclustering. Bond and Brockett (1987) interpreted this result as supporting their contention that persons within a given social context are organized in memory by personality. Persons' similarity in terms of personality traits and other individual characteristics, though, tends to be modestly correlated with social proximity in socially bounded communities (Arabie, 1984; Breiger & Ennis, 1979; Iannucci, 1992). Therefore, it might be that weak clustering by personality could be observed even when subjects are actually associating according to a community's social structure. In addition, it is theoretically more parsimonious to assert

that social structural principles organize persons in memory
not only at the level of relatively discrete social
contexts/communities but also among persons within social
communities. It remains for future work, though, to
ascertain the relative merits of social structural and
personality based explanations of the organization of
persons in memory.

The salience of persons in the minds of community
members is also shaped by social structural factors. Both
community- and ego-centered tendencies exist in which
persons a subject is likely to recall and how early those
persons are mentioned in recall. In the three studies
reviewed here, the community-centered biases included
persons' visibility and status. In the organizational
department, persons' likelihood of recall was related to the
regularity of their physical presence among others in the
department, which mirrors a similar finding by Freeman, et
al. (1987). In the religious fellowship, both frequency and
serial order patterns were also predicted by visibility,
measured by persons' centrality in the social network. This
result resembles Jennings' (1937) observation that at a
state residential school for girls, the girls who were more
likely recalled also received more sociometric choices than
those girls less frequently mentioned in a free recall task.
Visibility in terms of social structural centrality, while
likely highly correlated with visibility in terms of

regularity of physical presence, may also reflect aspects of status, even in egalitarian communities. For instance, centrality is positively related to perceived leadership in laboratory communication networks (Bavelas 1949; Freeman, Roeder, & Mullholland, 1979) and centrality in the friendship network of employees in a formal organization was positively associated with reputational power (Krackhardt, 1990). In addition, Mazur (1973) observed in his review of small group research on status that "high ranked members usually participate more than low ranked members in group interactions" (p. 514). Indeed, status also partially described persons' salience in the organizational department, where persons of higher status tended to be mentioned earlier in recall than lower status persons.

The status hierarchy of individuals in a community may be just as essential for a community member to know as affiliation patterns. Status hierarchies have also been shown in the animal behavior and social science literature to have wide ranging social, economic, political, psychological, physiological, and reproductive effects, and knowledge of a community's status ordering would also offer a competitive edge over others. Accordingly, research suggests that humans, monkeys, and other animals can readily and reliably identify the status of their conspecifics (e.g., Cheney & Seyfarth, 1990; Gouzoules, et al., 1984; Mazur & Cataldo, 1989; Popp, 1987; Sluckin & Smith, 1977).

Thus, the status component of persons' salience in memory
might be a cognitive manifestation of the evolutionary
importance of status.

The ego-centered factor of persons' salience in memory
is how close persons are to an individual in the community's
social structure. In each of the three studies reviewed
earlier, persons closer to a subject in the community's
social structure were recalled more frequently and/or
earlier in recall than persons farther away from a subject.
Previous research has also shown that persons with whom
subjects had strong ties or intense interaction were more
frequently recalled than persons with whom they were more
weakly linked (Bahrick, Bahrick, & Wittlinger, 1975; Riegel,
1973; Sudman, 1988; Sudman, 1985 is an exception, however).
This ego-centered factor of persons' salience may reflect
the differential amount of contact an individual has with
others. Persons with whom one regularly and frequently
interacts may become prominent in memory simply due to the
great amount of exposure to them. Furthermore, persons
close to oneself in a community's social structure tend to
be one's friends, allies, and confidants--i.e., persons for
whom an individual feels the strongest degree of positive
affect.

The three studies reviewed in this paper also showed
the reliability and uniformity of patterns in the recall of
persons. Subjects' associative, frequency, and serial order

patterns were stable across different interviews, and in each study subjects displayed homogeneous recall patterns. Regardless of whether subjects used a different recall strategy (such as recalling persons in alphabetical order of their names or by the locational arrangement of their offices), subjects' recall processes still seemed to be affected (or even limited) by the organization of the underlying, social structurally based cognitive structure.

Other Relevant Research on the
Organization of Persons in Memory

There is additional recent research that demonstrates that persons are organized in memory along social structural lines. When people recall their kin, genealogical tree structures and kin classes play a role in associative patterning (Alexander, 1976; Hammel, 1984; Sanday, 1969). Additionally, Bond and Brockett (1987) and Bond and Sedikides (1988) found that subjects retrieved the name of a person faster when given a social context cue than when given a personality trait cue. When both social context and personality cues were given, person retrieval was quicker when the social context cue was first. Similar to the observation in the organizational department study that misnamings occurred between pairs of persons that worked especially close together, Fiske, Haslam, and Fiske (1991)

and Fiske (in press) demonstrated that in person confusions (e.g., misnaming a person, misdirecting an action), errors were patterned along relationship mode and social context lines. Moreover, in several experiments, Sedikides, Olsen, and Reis (1993) presented subjects with information items about fictionalized persons. They asked subjects to recall these information items and then match items with persons. When the information items concerned multiple pairs of persons connected by some type of relationship, such as marriage, subjects tended to cluster items in recall by couple and confuse items for persons within a couple in the matching task.

Furthermore, Matsuzawa (1989) showed that a symbol manipulating chimpanzee displayed both ego-centric and species-centric biases in the serial order of naming human and chimpanzee individuals (all known by the subject) in a picture naming task. When presented with a pair of pictures, one of a human caretaker and another of a chimpanzee, this chimpanzee subject tended to name the chimpanzee first. When the pair of pictures presented to the subject depicted two chimpanzees, one of which was the subject herself, she tended to name herself first.

This related research provides bolstering evidence that persons (and information relating to them) are organized in memory according to social structural principles. However, when individuals do not personally know some set of persons

or do not share membership in some community with those persons, social structural factors do not seem to be present in memory organization. Associative patterns in the recall of famous persons are related to individual characteristics, such as age and occupation (Robertson, 1990; Robertson & Ellis, 1987; Roediger & Crowder, 1976; Riegel, 1973). Rubin and Olson (1980) demonstrated that when college students recalled the names of their professors, they clustered professors by academic discipline. As Mandler (1979) and Freeman, et al. (1987) have asserted, experience with a given set of stimuli is the basis for organization in memory. Since subjects typically have no personal contact with famous persons or comprehensive knowledge of the social relationships among these persons, these persons are organized in memory not in terms of social structure but in terms of individual characteristics. Similarly, the college students mostly likely observed and interacted with their professors in classroom and other educational settings in which only one professor was present at a time. Such an arrangement would not permit students access to much information about the social network among professors (although academic discipline most probably was related in some way to interaction patterns). Thus, because student-professor contact was primarily focused on instruction in some academic subject, the organization of professors in students' memories was based on discipline.

The three studies reviewed in this paper, though, suggest that if an individual were to become a member of one of these communities (e.g., Hollywood stars, college faculty), the organization of community members in her/his memory would eventually come to be based on the community's social structural features. Moreover, the phenomenon that individuals are aware of particular persons (such as famous persons) but do not personally know them is a very recent development in the evolution of human societies. This fact suggests that the fundamental aspects of person memory are most fruitfully studied by examining how individuals remember persons with whom they interact in natural social contexts.

Affiliation and Dominance as
Principal Dimensions of Social Cognition

The three studies reviewed in this paper indicated that cognitive structures of community members are based on interaction/affiliation patterns, and that the salience of persons in memory seem to be related to persons' dominance (as indicated by status and centrality) and social closeness to an individual subject (an aspect of interaction/ affiliation). These two dimensions, affiliation and dominance, are the same that have been discovered in other research on social cognition, including the judged

similarity of interpersonal relationships (Wish, Deutsch, &
Kaplan, 1976), the judged similarity of personality traits
(White, 1980) and observers' ratings of individuals'
behavior in a wide variety of social contexts (Foa, 1961).
Thus, not only do these two fundamental facets of social
structure organize persons in memory, but they also shape
person and relationship perception. Clearly, the social
cognitive abilities of accurately perceiving and remembering
affiliation patterns and dominance hierarchies are required
to function in the complex social communities of many
species. Indeed, it might be that these social cognitive
skills led to and determined the nature of the "higher"
cognitive abilities which evolved in humans and other
primates (Byrne & Whiten, 1988; Humphrey, 1976; Jolly, 1966;
Lachman & Lachman, 1979).

Proposed Agenda for Future Research

The three studies summarized in this paper are initial
investigations of the organization of persons in memory.
This work could be extended by conducting research in other
communities differing in composition, examining other person
recall tasks, and analyzing other aspects of recall.
Ideally, all future research should directly compare social
structural and personality variables as bases for patterns
in the recall of persons. It would be worthwhile to study

the recall of persons in communities varying along developmental lines (e.g., young children (even toddlers), senior citizens, developmentally disabled) in order to determine when in development the social structural organization of persons in memory begins and how long it persists. Research on patterns in the recall of persons in communities outside of United States is necessary to test further the cross-cultural generality of results reported in this paper. It would be interesting to see if specific results, such as the logarithmic relationship between IRT and proximity in a community's social structure for adjacently recalled pairs of persons, are replicated in other communities.

Patterns in Alzheimer's patients' recall of persons might also be examined to see if the disruption of the semantic organization of words in memory caused by that disease (Chan, Butters, Paulsen, Salmon, Swenson, & Maloney, in press) is matched by degradation of the social structural organization of persons in memory. This type of research would explore further whether lexical items and persons are part of independent memory systems, building on work that has shown that names of persons are neuropsychologically distinct from lexical labels. There have been reports of aphasic patients whose ability to retrieve acquaintances, relatives, and/or famous persons' names (in contrast to lexical items from semantic domains and generic first names

such as Mary and Bill) was selectively preserved or impaired
(McKenna & Warrington, 1980; Semenza & Zettin, 1988, 1989;
Warrington & McCarthy, 1987). Furthermore, the patterns in
symbol manipulating apes' recall of conspecifics might also
be studied, perhaps with methodologies similar to those used
by Buchanan, Gill, and Braggio (1981) and Matsuzawa (1989).
Such cross-species work would provide an indirect test of
the evolutionary interpretation of the social structural
organization of persons in memory.

Other types of person recall tasks should also be
studied to broaden the understanding of person memory in
natural contexts. While several researchers have analyzed
patterns in the recall of acquaintances, none have yet
investigated the role of interaction patterns as an
associative factor within and between social context
clusters of acquaintances. McCarty (1992) collected data
which are suited for this kind of analysis. In addition,
associative patterns have not been studied for relation-
specific person recall questions (e.g., who are the persons
with whom you discuss important matters?) that are common to
many surveys of ego networks (e.g., Burt, 1986; Fischer,
1982; Wellman, 1979).

Moreover, all studies of associative patterns in the
recall of persons to date have analyzed each individual
subject's recall as a whole. This type of overall analysis
of a subject's recall does not indicate whether the strength

of associative patterning changes <u>over the course</u> of that
subject's recall. Bousfield (1953) reported that in the
recall of words from different semantic domains/categories,
subjects' semantic clustering by domain decreased over the
course of recall, suggesting that associations made during
the last stages of recall were essentially random. However,
in both the religious fellowship and organizational
department studies, subjects' temporal patterns were clearly
related to perceived interaction patterns throughout the
course of recall. Hence, I hypothesize that the degree of
clustering by social structural variables in the recall of
persons will remain constant over the course of recall.

Finally, there are other lines of research that could
be followed to investigate further the cognitive structure
of persons. Perhaps one of the most promising approaches is
the speeded picture naming procedure (Vitkovich, Humphreys,
& Jones, 1993). In this type of experiment, subjects are
presented with pictures of objects and asked to respond
rapidly (usually after some predetermined length of time),
perhaps with the first name that comes to mind. Since the
allotted time is not always long enough for subjects to
recognize the object and retrieve its appropriate name, this
procedure tends to induce errors in subjects' responses. In
the case of objects from semantic domains/categories, the
naming errors are patterned along semantic and visual
similarity lines (Vitkovich, et al., 1993). This same

procedure could be used for a speeded person naming experiment, where individuals from a socially bounded community named pictures of fellow community members. I hypothesize that the resulting errors in subjects' responses would be between pairs of persons who are closer to each other in the community's social structure than would be expected by chance.

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APPENDIX A

VISIBILITY-ORIENTED SERIAL ORDER RECALL

PROCESS USED IN SIMULATIONS IN CHAPTER 2

The following paragraphs detail the visibility-oriented serial order recall process used in simulating paths. In generating a simulated path, the persons to be included in that simulated path are first selected probabilistically according to the proportion of subjects who recalled each person. Then, the output serial positions for the persons selected for a simulated path are determined probabilistically for each successive output serial position. Given the n persons selected for a simulated path, the probability that a person i who has not yet been output will be output next is

$$\frac{f_i g_i}{\sum_{i=1}^{n} f_i g_i}$$

where f_i is person i's frequency of mention, and g_i equals 1 if person i has not yet been output and 0 otherwise. Thus, this process is Markovian since the probability of any person being output next is independent of the order of persons output previously. This sampling process is also without replacement because a person could only be output once.

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When persons' raw frequencies of mention were used in this simulation process, the serial order patterns (i.e., the correlations between serial position and frequency) in the simulated paths were not as strong as those in subjects' observed paths. By transforming (i.e., raising to a power) persons' frequencies of mention, we were able to produce simulated paths which displayed serial order patterns almost identical to those observed in subjects (see text).

APPENDIX B

STATUS AND ALPHABETICALLY-ORIENTED SERIAL ORDER RECALL

PROCESSES USED IN SIMULATIONS IN CHAPTER 3

The following paragraphs detail the status- and
alphabetically-oriented serial order recall processes used
in simulating paths (this framework was first presented in
Brewer and Yang, 1993). In generating a simulated path, the
persons to be included in that simulated path are first
selected probabilistically according to the proportion of
subjects in the first interview who recalled each person.
Then, the output serial positions for the persons selected
for a simulated path are determined probabilistically <u>for
each successive output serial position</u>. Given the n persons
selected for a simulated path, the probability that a person
i who has not yet been output will be output next is

$$\frac{f_i g_i}{\sum_{i=1}^{n} f_i g_i}$$

where f_i is person i's status (relative alphabetical
position), and g_i equals 1 if person i has not yet been
output and 0 otherwise. Thus, this process is Markovian
since the probability of any person being output next is
independent of the order of persons output previously. This

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sampling process is also without replacement because a person could only be output once.

When persons' ordinary status and alphabetical position ranks were used in this simulation process, the serial order patterns (i.e., the correlations between output serial position and status/alphabetical position) in the simulated paths were not approximately the same as those in subjects' observed paths. By transforming (i.e., raising to a power) persons' status and alphabetical position ranks, I was able to produce simulated paths which displayed serial order patterns almost identical to those observed in subjects (see text).

QUICKBASIC PROGRAM CODE FOR CONTROL ANALYSIS OF CLUSTERING

```
CLS : LOCATE 1, 5, 1
PRINT "Welcome to SEGCLUST": PRINT
PRINT "This program computes path length statistics for
individual subjects'"
PRINT "recall paths where a path consists of segments of
associations that are separated"
PRINT "by some type of interruption, such as recall
according to some quali-"
PRINT "tatively different type of association." : PRINT
PRINT "The first row of your input file should consist of
the subject's path,"
PRINT "with the items identified by their identification
numbers and separated"
PRINT "by spaces.  The next row(s) should have the
interruptive sequences of items"
PRINT "(called 'mandatory sequences' since they must be
accounted for in measuring"
PRINT "clustering), with the item numbers appearing in the
same exact order "
PRINT "as they are in the subject's observed path.
Beginning with the next row"
PRINT "after the mandatory sequences, your input file should
also include an"
PRINT "n x n associative matrix that holds the pairwise
similarity/dissimilarity"
PRINT "values among all n items that particular subject
recalled.  The rows"
PRINT "and columns need to be ordered in terms of the items'
numbers.  The"
PRINT "subject's path (and mandatory sequences) should not
have any repetitions.": print
PRINT "Press any key to continue."
3 a$ = INKEY$
IF a$ = "" THEN GOTO 3
CLS : LOCATE 1, 1, 1
PRINT "To begin the program, you need to know the number of
items in a subject's"
PRINT "path, the total number of items possible (i.e. the
highest item number),"
PRINT "the number of mandatory sequences, the number of
items in each mandatory"
PRINT "sequence, and the subject's total observed
pathlength.": PRINT
PRINT "This program computes path length statistics
(estimated [from a speci-"
```

```
PRINT "fied number of randomly generated paths through the
assoc. structure]"
PRINT "mean and variance of paths, path length clustering
z-score based on"
PRINT "normal approximation of distribution of randomly
generated path "
PRINT "lengths, and the proportion of randomly generated
paths that were"
PRINT "shorter/longer than the subject's observed path
length.": PRINT

PRINT "Press any key to continue."
4 a$ = INKEY$
IF a$ = "" THEN GOTO 4
CLS : LOCATE 1, 1, 1
PRINT "Finally, the program creates a file called 'sc.dat'
for aid in calculations."
PRINT "It takes up to a few megabytes if you use 10,000
trials and"
PRINT "it may be erased.  Just make sure you have enough
spare storage space"
PRINT "on your hard disk before running this program.   "
PRINT
PRINT "Press any key to continue."
5 IF INKEY$ = "" THEN GOTO 5 ELSE GOTO 10

10 CLS : LOCATE 1, 1, 1
INPUT "Filename for input (path = first row, mand. sequences
in next rows, then assoc. matrix)"; ifile$: PRINT
INPUT "How many random paths do you want to run"; ntrials:
PRINT
INPUT "How many items in the subject's recall path"; nitems:
PRINT
INPUT "How many total items possible"; nposs: PRINT
INPUT "How many interruptive or mandatory sequences are
there"; nseq: PRINT
PRINT "Please type in the number of items for each of the
mandatory sequences."
PRINT
DIM seqnitem(nitems)
FOR i = 1 TO nseq
        PRINT "Mandatory sequence "; i; ": ";
        INPUT "How many items"; seqnitem(i): PRINT
        msitems = msitems + seqnitem(i)    'total # of items
        in m.s.'s
        IF seqnitem(i) > maxseqn THEN maxseqn = seqnitem(i)
NEXT i

INPUT "What is the subject's observed path length"; obsleng:
PRINT
INPUT "What label should be used to identify this subject";
slabel$: PRINT
```

```
17 INPUT "Does the assoc. matrix consist of proximities
('p') or distances ('d')"; mtype$
CLS : LOCATE 1, 1, 1
PRINT "Reading in data . . . "

RANDOMIZE TIMER

DIM presence(nposs)          'whether an item was recalled by
the subject
DIM mand(nposs)              'whether an item begins or ends a
mand. seq.
DIM mandseq(nseq, maxseqn)   'identifies an item in a
particular mand. seq.
DIM switch(nposs)            'item's reachability in path
generation (1=no)
DIM x(nposs, nposs)          'associative structure matrix
DIM prob(nposs)              'prob. a given item will be
selected at that point in the path
DIM ranprob(nposs)           'item's position along unit
vector for random selection at that point in the path
DIM middle(nposs)            'marks items that occur in middle
of mand. seq.'s
DIM nextitem(nposs)          'indicates the item that is at
the opposite end of the mandatory sequence from the
subscripted item (where path jumps to from one end of the
mand. seq. to the other)
DIM nodes(ntrials)
DIM word(nitems)
DIM item(nitems)
DIM itemprob(nitems)
DIM invdist(nitems)
DIM pathleng(nitems)
DIM meanpath(nitems)
DIM sumsq(nitems)
DIM sdpath(nitems)
DIM sumpath(nitems)
DIM distprob(nitems)
DIM prop(nitems)

OPEN ifile$ FOR INPUT AS #1

'reading in observed path, determining which items = present
FOR i = 1 TO nitems
        INPUT #1, d
        presence(d) = 1
NEXT i

'reading in mandatory sequences, noting which items begin
and end mandatory sequences, and noting which items path
should jump to once a beginning or end item has been has
been hit
```

```
FOR i = 1 TO nseq
        FOR j = 1 TO seqnitem(i)
                INPUT #1, y
                mandseq(i, j) = y
                IF j = 1 THEN mand(mandseq(i, j)) = 1
                IF j = seqnitem(i) THEN GOTO 25 ELSE GOTO 28
25              nextitem(mandseq(i, 1)) = mandseq(i,
                seqnitem(i))
                nextitem(mandseq(i, seqnitem(i))) =
                mandseq(i, 1)
                mand(mandseq(i, seqnitem(i))) = 1
28              IF j > 1 THEN GOTO 30 ELSE GOTO 35
30              IF j < seqnitem(i) THEN middle(mandseq(i,
                j)) = 1
35      NEXT j
NEXT i

'reading in associative matrix
FOR i = 1 TO nposs
        IF presence(i) = 0 THEN GOTO 40
        FOR j = 1 TO nposs
                IF presence(j) = 0 THEN GOTO 37
                IF EOF(1) THEN END
                INPUT #1, x(i, j)
37      NEXT j
40 NEXT i

'calculating length of mandatory sequences to be added to
each path as a constant
FOR i = 1 TO nseq
        FOR j = 1 TO seqnitem(i)
                IF j = 1 THEN from = mandseq(i, j): GOTO 45
                too = mandseq(i, j)
                constant = constant + x(from, too)    'sum of
                mand. seq. lengths
                from = too
45      NEXT j
        from = 0
        too = 0
NEXT i

'running random paths

OPEN "sc.dat" FOR OUTPUT AS #2

counter = 1: CLS : LOCATE 3, 5, 1: PRINT "Trials
completed:";

FOR i = 1 TO ntrials

IF i / (counter * 100) = 1 THEN LOCATE 3, 24, 1: PRINT
counter * 100: counter = counter + 1
```

```
50 nodeposs = (nitems - (msitems - (2 * nseq)))   '# items
recalled minus items in middle of mand. seqs.

left = nodeposs

52 FOR z = 1 TO nposs            'assigning item's chance
prob. of selection along unit vector
        IF presence(z) = 0 THEN GOTO 56
        IF middle(z) = 1 THEN GOTO 56
        IF switch(z) = 1 THEN GOTO 56
        IF left = 0 THEN END
        IF left = 1 THEN n = z: endpath = 1: GOTO 60
        prob(z) = 1 / left
        sranprob = sranprob + prob(z)
        ranprob(z) = sranprob
56 NEXT z
IF sranprob = 0 THEN END
f = RND                          'randomly selecting next item
FOR u = 1 TO nposs
        IF presence(u) = 0 THEN GOTO 58
        IF middle(u) = 1 THEN GOTO 58
        IF switch(u) = 1 THEN GOTO 58
        IF f < ranprob(u) THEN n = u: GOTO 60    'next item
        selected
58 NEXT u

60 IF mand(n) = 1 THEN GOTO 62 ELSE GOTO 65      'mand. seq.
called up
62 switch(n) = 1:
   IF node = 1 THEN pathleng = pathleng + x(item, n)
   nextitem = nextitem(n): n = nextitem
   switch(n) = 1:
   sranprob = 0: left = left - 2: item = n: node = 1
   IF left = 0 THEN GOTO 80
   GOTO 52

65 IF node = 0 THEN GOTO 68      ' node=0 if first item
   recalled, 1 otherwise
   pathleng = pathleng + x(item, n)      ' adding next link
   to pathlength
68 item = n: switch(n) = 1: sranprob = 0: node = 1
   IF endpath = 1 THEN GOTO 80
   left = left - 1
   GOTO 52

80 'clearing variables for that path
        FOR w = 1 TO nposs
                switch(w) = 0
                ranprob(w) = 0
                prob(w) = 0
85      NEXT w
        node = 0: endpath = 0
```

```
90 pathleng = pathleng + constant
sum# = sum# + pathleng
PRINT #2, pathleng

IF mtype$ = "P" THEN GOTO 94
IF mtype$ = "p" THEN GOTO 94
IF mtype$ = "d" THEN GOTO 92
IF mtype$ = "D" THEN GOTO 92

92 IF pathleng < obsleng THEN numsmall = numsmall + 1
IF pathleng = obsleng THEN numsmall = numsmall + 1: GOTO 96
94 IF pathleng > obsleng THEN numlarge = numlarge + 1
IF pathleng = obsleng THEN numlarge = numlarge + 1
96 pathleng = 0
NEXT i

meanpath# = sum# / ntrials
CLOSE #2

LOCATE 7, 1, 1: PRINT "Finishing final calculations . . . ":
PRINT

'calculating standard deviation of randomly generated paths
OPEN "sc.dat" FOR INPUT AS #3

FOR i = 1 TO ntrials
        INPUT #3, p
        sumsq# = sumsq# + ((meanpath# - p) ^ 2)
NEXT i
sdpath# = SQR(sumsq# / ntrials)
propsmll = numsmall / ntrials
proplrge = numlarge / ntrials
zobs = (obsleng - meanpath#) / sdpath#

CLS : LOCATE 1, 1, 1

1000 'printing results to screen
PRINT "SEGCLUST clustering results for "; slabel$ : PRINT
PRINT "Number of trials = "; ntrials: PRINT
PRINT "Subject's observed path length = "; obsleng: PRINT
PRINT "Mean path length = "; meanpath#; "   Standard
deviation of paths = "; sdpath# : PRINT
PRINT "Segmented path clustering z-score = "; zobs : PRINT

IF mtype$ = "P" THEN PRINT "Proportion of random paths as
large or larger = "; proplrge
IF mtype$ = "p" THEN PRINT "Proportion of random paths as
large or larger = "; proplrge
IF mtype$ = "d" THEN PRINT "Proportion of random paths as
small or smaller = "; propsmll
IF mtype$ = "D" THEN PRINT "Proportion of random paths as
small or smaller = "; propsmll
```

```
PRINT : PRINT : PRINT : PRINT

LPRINT "SEGCLUST clustering results for "; slabel$ : LPRINT
LPRINT "Number of trials = "; ntrials: LPRINT
LPRINT "Subject's observed path length = "; obsleng: LPRINT
LPRINT "Mean path length = "; meanpath#; "  Standard
deviation of paths = "; sdpath# : LPRINT
LPRINT "Segmented path clustering z-score = "; zobs : LPRINT
IF mtype$ = "P" THEN LPRINT "Proportion of random paths as
large or larger = "; proplrge
IF mtype$ = "p" THEN LPRINT "Proportion of random paths as
large or larger = "; proplrge
IF mtype$ = "d" THEN LPRINT "Proportion of random paths as
small or smaller = "; propsmll
IF mtype$ = "D" THEN LPRINT "Proportion of random paths as
small or smaller = "; propsmll
LPRINT : LPRINT : LPRINT : LPRINT

END
```

APPENDIX D

THE STUDENT COMMUNITY DATA

Informants' recall lists are identified by informant number
(as in Table 1.1). Recalls proceed from left to right,
wrapping onto next line if necessary. Numbers in recall
lists refer to persons. Self-mentions and intrusions are
not included in these lists.

1   20 30 7 22 12 9 25 41 8 16 10 1 32 36 31 29 17 2 18 28 5
     6 13

2   30 7 36 5 23 6 13 25 41 9 8 16 10 12 22 1 18

3   23 7 20 12 16 9 10 17 6 13 25 8 22 39

4   16 10 12 41 8 25 22 17 18 36 31 23 20 30 7 28 13 1 2 29
     34 27 38 40 24 6

5   12 10 9 8 22 25 41 23 30 20 7 6 13 17 40 19 18 1 32 31
     28 37 38 27 36 14

6   16 9 30 12 22 31 20 23 10 8 41 7 13 6 5 2 19 27 38 14 17
     28 18 11 26 4

7   12 16 9 41 22 8 25 2 19 23 20 13 38 14 34 27 17

8   17 13 25 22 3 34 16 12 8 28 18 29

9   16 9 10 41 8 25 22 23 30 7 20 17 13 29 38 31 22 28 36

10   34 31 12 16 25 41 8 10 22 9 20 23 6 13 11 4 5 1 36 37 39
     32 7 27 38 14 29 2

11   17 28 14 22 36 34 38 27 13 20 23 25 9 41 8 7

12   17 9 10 1 19 13 28 23 16 19 41 37 2 36 31 32 14 3 22 20

13   22 31 20 23 32 18 28 5 29 13 6 4 17 16 41 10 9 25 11

14   35 15 21 2 19 40 1 39 6 4 11 33 17 25 10 27 22 31 36 3

15   11 6 37 40 19 2 1 13 9 38 16 4 28

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Retest

9   9 16 22 8 10 41 25 17 29 20 30 7 23 36 13 37

13   32 28 18 13 11 5 6 37 19 25 9 16 10 22 14 38 27 17 34 31
     20 2 29 4

Persons' cohort memberships

Person Number	Cohort Year
1	5
2	5
3	2
4	6
5	6
6	6
7	1
8	2
9	2
10	2
11	6
12	2
13	4
14	3
15	7
16	2
17	3
18	4
19	5
20	1
21	7
22	2
23	1
24	5
25	2
26	8
27	5
28	4
29	7
30	1
31	3
32	4
33	6
34	3
35	9
36	4
37	5
38	3
39	5
40	5
41	2

APPENDIX E

THE RELIGIOUS COMMUNITY DATA

Subjects' recall lists are identified by subject numbers.
Recalls proceed from left to right, wrapping on to the next
line(s) if necessary. Numbers in recall lists refer to
persons. Self-mentions and intrusions are not included in
these lists.

```
1     8   48   65   25   81   18   71   38   37   53   63   30   51   52
     28   84   22   50   46   83   19   76   98   42   21   55   69   59
     29   79   12   32


2    84   51   83   50   28   18   25   23   26   27   79   21


3    37   38   84   25   23   29   59   67   19   76   79   41   51   26
     18   71   33   83   50   68   13   14   75   39   31   32   12    1
     66   24   28   22   82


4    19   76   79   81   18   71   51   52   59   29   66   39   37   38
     48   17   15   33   21    1   32   53   63   84   83   28    9   22
     62   31   39   12   67   68   54   75


5    13   14   17   15   52   51   84   50   12    4   37   38   81   31
     39   53   63   76   19   21   79   33   82   23   25   26   48   90
     66   54


6    18   79   12   66   19   76   53   63   67   68   83   50   51   26
     52   28   22   13   14   91   23   89    5   95   86   84   55   69
     71   70   94


7    50   59   29   21   33   25   23   18   45   60   53   63   81   38
     37   35   17   96   66   84   56   55   39   31   79   51   26   52
     19   76   28


8    76   19   15   67   40   37   83   13   50   59    2   25   23   65
     18   21   32   20    8   92   38   53   63   57   47   17   14   16
     11   97   66   54   12   98   26   51   42   99   28   52   58   49
     73   55   69


9    18   12   50   52   84   51   26   25   23   13   14   22   66   29
     79   15   19   76   67   83   11    7   77   65   48   82   78   88
     27    4   68    5    2   44   60   73   74   53   63   62   72   61    1


10   81   50   67   76   19   53   63   52   84   71   70   44   21   18
     59   29   79   17   16   68   36   25   23   13   14    6    3    5
     87   23   75   99   91   83   33   37   38   39   31   12   18    4
```

```
11    12  18  19  71  27  59  29  79  81  53  33  52  51  13
      14

12    79  41  27  59  18  24  21  12  48  65  39  37  38  50
      83  68  33  67  84  51  15  52  25  23  26  31  66  10
      76  19  53  63  12   4  60  73  21  28  69  55  33  14
      13   6   5  93  44  71  70  74  11   7

13    18  59  29  79  23  66  12  55  69  76  19  67  52  24
      63  53  51  26  25  50  33  21  41

14    50  63  84  27  18

15    18  51  84  28  52  27  29  59  24  69  55  65  23  51
      26  53  90  41  76  19  67  68  12  66  46  43  17  15
      79  41  42  40  31

16    25  29  27  12  59  66  19  76  67  52  84  51  15  48
      65  35  32  78  21  33  31

17    82  29  59  55  69  53  63  84  51  24  28  52  15  27
      31  76  67  19  12  18  23  25  66

18    67  52  28  53  63  19  21  18  79  84  51  80  12  33
      14  13  82  23  25  68  79  41  59  29   8  34  83  22
      27  26  31  15  17  69  55  45  98  24  42

19    81  80  63  64  76  19  18  33  21  50  67  93  22  83
      68  51  26  23  25  69  55  84  54  56  82  48  52  58
      28

20    18  84  81  59  79  12  48  76  19  51  50  21  33  29
      15  28  52  63  53  17  15  41  42  71  70  44  25  82
      31  38  37

21    28  52  58  19  76  22  50  83  68  39  84  27  29  79
      15  51  26  23  25  12   4  21  33  32   8  80  53  63
      41  42  48  37  38  75  18 106  46  43 100 101  71
      70  75  82  66  59  60  73  67  69  55

22    51  84  12  59  50  79  52  66  81  63  53  19  76  67
      21  29  27  24  77  23  25  69  55  32  28

23    76  19  79  18  50  25  23  31  41  15  17  52  51  84
     105  67  21  33  12  44 104 103  46  43

24    71  18  44  76  67  38  37  24 102  16  17   8  32  82
      12  84  52  51  52  28  53  63 105  66  50  68  70
      33  21  37  59  29  10  75
```

```
25    81  18  51  50  76  19  53  63  66  21  33  55  69  84
      52  67  24  82  37  38  12  61   1  17  15  34  10  48
      79  29  59  31  54  27
```

Translation between subject and person numbers

Subject number	Person number
1	82
2	32
3	52
4	50
5	28
6	33
7	12
8	84
9	59
10	51
11	65
12	29
13	27
14	-- (never recalled)
15	63
16	23
17	21
18	76
19	53
20	67
21	31
22	18
23	24
24	19
25	71

Classification of persons by gender

```
Males:   1 3 5 6 8 9 12 13 14 15 16 17 18 20 21 24 26 27 29
         30 31 32 33 39 40 43 44 46 47 50 51 55 56 61 68 70
         71 73 74 77 78 79 80 82 83 86 88 95 96 102

Females: 2 4 7 10 11 19 22 23 25 28 34 35 36 37 38 41 42
         45 48 49 52 53 54 57 58 59 60 62 63 64 65 66 67
         69 72 75 76 81 84 87 89 90 91 92 93 94 97 98 99
         100 101 103 104 105 106
```

Classification of persons by section membership

College: 1 2 4 5 7 8 9 10 11 12 15 16 17 18 19 20 21 23
         24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 41
         43 44 46 47 48 50 51 52 53 54 58 59 60 61 63 64
         65 66 67 68 70 71 73 74 75 76 77 78 79 80 81 82
         84 90 102 103 104 105 106

High School: 3 6 13 14 22 39 40 42 45 49 57 62 83 86 87
             88 89 91 93 94 95 96 97 98 99 100 101

Classification of persons by first letter of first name

A: 3 15 19 75 76

B: 40 67 86 87

C: 4 34 37 43 77 91

D: 1 13 50 68 83 88

E: 104

F: 5 103

G: 89

H: 2

I: 59 90

J: 6 18 21 22 23 24 25 29 30 33 36 41 44 45 65 78 80 82 93
   94 100

K: 7 8 20 32 60 92

L: 9 16 35 38 53 63 64 70 81 95 102

M: 10 46 55

N: 57

O: 47 106

P: 14 17 62 96 101

Q: 11

R: 69

```
S: 12 27 31 39 54 56 66 72 84 97 98 105

T: 26 42 48 51 71 79 99

W: 28 52 58 61

Y: 49 73 74
```

Sets of persons with same first name

```
19 76

26 51

13 50 68 83

31 39

23 65

53 63 64

28 52 58

78 82

20 32
```

Sets of persons who are kinship related

```
4 12 5

6 3

7 11

8 102

13 14

15 17

22 28 30

23 26 25

24 40 41 42 99   (24 and 99 are not kinship related)
```

Sets of persons who are kinship related (continued)

37 38 39

43 46 100 101

34 49

51 52 45

55 56

57 58

59 60 73 74

67 68 69

70 71

80 81

83 84

66 94

77 103

The following eight pages show the aggregated perceived
social proximity matrix. Rows and columns refer to persons.
Numbers in the cells of the social proximity matrix
represent proportions with decimal points omitted. Unity is
represented by "1.". There were no social proximity data
for persons 30, 92, 103, 104, 105, and 106. The rows and
columns for these persons are included in the matrix for
consistency. The cell values for these persons thus should
not be regarded as genuine. Although there were social
proximity data for person 85, this person was not classified
as being recalled by any subject according to the objective
person identification rules described in Chapter 2.

```
      1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26
 1    1.  00  29  00  11  25  00  00  00  11  00  00  29  38  00  00  00  00  11  00  00  11  00  00  00  00
 2    00  1.  00  00  00  00  00  20  00  00  00  20  00  00  20  00  00  20  00  00  00  00  00  00  00  00
 3    29  00  1.  00  63  1.  00  00  00  11  00  00  88  89  00  00  00  00  00  00  11  00  00  11  00  00
 4    00  00  00  1.  17  00  00  00  00  00  33  00  00  00  00  00  00  00  00  00  00  00  00  00  17  17
 5    11  00  63  17  1.  67  00  00  00  10  00  10  57  56  00  00  00  00  00  00  00  10  00  00  10  00
 6    25  00  1.  00  67  1.  00  00  00  10  00  00  88  89  00  00  00  00  00  00  10  00  00  10  00  00
 7    00  00  00  00  00  00  1.  25  00  00  1.  00  00  00  13  13  00  00  13  00  00  00  13  00  13  13
 8    00  20  00  00  00  00  25  1.  00  00  30  27  00  00  36  30  18  18  09  00  18  00  18  18  27  18
 9    00  00  00  00  00  00  00  00  1.  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
10    11  00  11  00  10  10  00  00  00  1.  00  00  13  20  00  00  00  09  09  00  09  50  09  00  09  00
11    00  00  00  00  00  00  1.  30  00  00  1.  00  00  00  10  11  00  00  10  00  00  00  10  00  10  10
12    00  20  00  33  10  00  00  27  00  00  00  1.  00  00  36  10  18  27  18  00  18  00  18  18  27  27
13    29  00  88  00  57  88  00  00  00  13  00  00  1.  1.  00  00  00  00  00  00  13  00  00  13  00  00
14    38  00  89  00  56  89  00  00  00  20  00  00  1.  1.  00  00  00  00  00  00  10  11  00  00  00  00
15    00  20  00  00  00  00  13  36  00  00  10  36  00  00  1.  30  27  27  18  00  18  00  27  09  27  18
16    00  00  00  00  00  00  13  30  00  00  11  10  00  00  30  1.  30  10  10  00  10  00  20  10  30  10
17    00  00  00  00  00  00  00  18  00  00  00  18  00  00  27  30  1.  36  18  00  27  10  18  09  18  09
18    00  20  00  00  00  00  00  18  00  09  00  27  00  00  27  10  36  1.  27  00  27  30  18  09  18  09
19    11  00  00  00  00  00  13  09  00  09  10  18  00  00  18  10  18  27  1.  00  27  10  27  09  27  09
20    00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  1.  00  00  00  00  00  00
21    00  00  11  00  10  10  00  18  00  09  00  18  13  10  18  10  27  27  27  00  1.  00  18  09  27  09
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93	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
94	00	00	00	00	00	33	00	00	00	00	25	25	25	00	00	00	25	00	00	25	00	00	00	00	00	00
95	00	00	00	00	00	00	00	00	00	00	00	00	14	00	00	00	00	00	00	00	00	00	50	00	00	00
96	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
97	00	00	00	00	00	00	00	00	00	00	00	00	20	00	00	00	00	00	00	00	00	00	25	00	00	00
98	00	00	00	00	00	14	00	13	00	17	00	00	00	00	00	00	00	00	00	17	00	00	00	13	00	
99	00	00	00	00	00	00	00	00	00	00	00	25	00	00	00	00	00	00	00	00	00	00	1.	00	00	00
100	00	00	00	00	00	00	00	00	00	14	14	14	00	00	00	1.	00	00	1.	00	00	00	00	00	00	
101	00	00	00	00	00	13	00	00	00	22	22	22	00	00	00	89	00	00	89	00	00	00	00	00	00	
102	20	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	20	20	20
103	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
104	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
105	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
106	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

```
      53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79
 54   11 1. 00 00 00 00 11 00 00 44 11 00 25 13 11 33 00 22 22 00 00 00 20 11 00 00 11
 55   09 00 1. 1. 00 00 00 00 00 00 09 00 00 00 00 09 36 00 00 00 00 00 00 00 09 00 00
 56   13 00 1. 1. 00 00 00 00 00 00 00 00 00 00 00 25 00 00 00 00 00 00 00 00 00 00 00
 57   00 00 00 00 1. 1. 13 13 00 00 00 00 00 13 00 00 00 00 00 13 00 00 13 13 00 13
 58   00 00 00 00 1. 1. 13 13 00 00 00 00 00 13 00 00 00 00 00 13 00 00 13 13 00 13
 59   18 11 00 00 13 13 1. 44 00 00 18 33 10 22 27 18 00 18 18 00 44 00 20 27 09 00 36
 60   00 00 00 00 13 13 44 1. 00 00 00 00 00 00 11 00 00 00 00 00 1. 67 00 11 11 00 22
 61   00 00 00 00 00 00 00 00 1. 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 62   00 44 00 00 00 00 00 00 00 1. 00 00 00 00 00 00 60 00 30 30 00 00 00 00 00 00 00
 63   45 11 09 00 00 00 18 00 00 00 1. 67 20 33 27 18 09 18 18 00 00 20 27 00 00 09
 64   67 00 00 00 00 00 33 00 00 00 67 1. 33 50 67 33 00 33 33 00 00 00 00 67 00 00 00
 65   20 25 00 00 00 00 10 00 00 00 20 33 1. 13 30 10 00 10 10 00 00 00 20 30 00 00 10
 66   33 13 00 00 00 00 22 00 00 00 33 50 13 1. 22 22 00 33 44 00 00 00 60 22 00 00 22
 67   36 11 00 00 13 13 27 11 00 00 27 67 30 22 1. 18 00 18 18 00 11 00 20 1. 09 00 18
 68   18 33 09 00 00 00 18 00 00 60 18 33 10 22 18 1. 00 36 36 00 00 00 20 18 09 00 09
 69   00 00 36 25 00 00 00 00 00 00 09 00 00 00 00 00 1. 00 00 00 00 00 00 00 00 00 00
 70   18 22 00 00 00 00 18 00 00 30 18 33 10 33 18 36 00 1. 91 00 00 00 40 18 00 00 09
 71   18 22 00 00 00 00 18 00 00 30 18 33 10 44 18 36 00 91 1. 00 00 00 60 18 00 00 09
 72   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 1. 00 00 00 00 00 00 00
 73   00 00 00 00 13 13 44 1. 00 00 00 00 00 00 11 00 00 00 00 00 1. 67 00 11 11 00 22
 74   00 00 00 00 00 00 00 67 00 00 00 00 00 00 00 00 00 00 00 00 67 1. 00 00 00 00 00
 75   20 20 00 00 00 00 20 00 00 00 20 00 20 60 20 20 00 40 60 00 00 00 1. 20 00 00 20
 76   36 11 00 00 13 13 27 11 00 00 27 67 30 22 1. 18 00 18 18 00 11 00 20 1. 09 00 18
 77   09 00 09 00 13 13 09 11 00 00 00 00 00 00 09 09 00 00 00 00 11 00 00 09 1. 00 09
 78   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 1. 00
 79   09 11 00 00 13 13 36 22 00 00 09 00 10 22 18 09 00 09 09 00 22 00 20 18 09 00 1.
 80   22 00 00 00 00 00 11 00 00 11 11 50 00 13 22 22 00 22 22 00 00 00 00 22 00 00 00
 81   18 00 00 00 00 00 09 00 00 10 09 33 00 11 18 18 00 18 18 00 00 00 00 18 00 00 00
 82   22 22 00 00 00 00 22 00 00 00 22 50 38 25 22 22 00 22 22 00 00 00 20 22 11 00 11
 83   10 13 10 00 00 00 00 00 00 22 00 00 11 00 10 20 00 00 00 00 00 00 00 10 20 00 00
 84   55 11 09 13 00 00 18 00 00 00 36 33 10 44 27 18 00 18 18 00 00 00 20 27 09 00 18
 85   00 00 00 00 00 00 00 00 00 00 00 00 50 00 25 00 00 00 00 00 00 00 00 25 00 00 00
 86   00 00 00 00 00 00 00 00 00 13 00 00 00 00 00 00 22 00 00 00 00 00 00 00 00 00 00
 87   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00 00 00
 88   00 00 00 00 00 00 00 00 00 1. 00 00 00 00 00 1. 00 00 00 00 00 00 00 00 00 00 00
 89   00 00 00 00 00 00 00 00 00 17 00 00 00 00 17 17 00 00 00 00 00 00 00 00 00 00 00
 90   20 00 10 13 00 00 00 00 00 00 10 00 11 22 10 00 00 10 10 00 00 00 20 10 00 00 00
 91   00 20 00 00 00 00 00 00 00 40 00 00 00 00 00 40 20 00 00 00 00 00 00 00 00 00 00
 92   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 93   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 94   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 25 00 00 00 00 00 00 00 25 00 00
 95   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 14 00 00 00 00 00 00 00 00 00 00 00
 96   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 97   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 98   00 14 00 00 00 00 00 00 00 00 00 00 00 13 00 00 13 00 00 00 00 00 00 00 00 00 00
 99   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 25 00 00 00 00 00 00 00 00 00 00 00
100   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
101   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 11 00 00
102   20 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 20 00 00
103   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
104   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
105   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
106   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
54	00	00	22	13	11	00	00	00	00	00	00	20	00	00	00	00	00	00	00	14	00	00	00	00	00	00	00
55	00	00	00	10	09	00	00	00	00	00	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
56	00	00	00	00	13	00	00	00	00	00	13	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
57	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
58	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
59	11	09	22	00	18	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
60	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
61	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
62	11	10	00	22	00	00	13	00	1.	17	00	40	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
63	11	09	22	00	36	00	00	00	00	00	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
64	50	33	50	00	33	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
65	00	00	38	11	10	50	00	00	00	00	11	00	00	00	00	00	00	00	13	00	00	00	00	00	00	00	00
66	13	11	25	00	44	00	00	00	00	00	22	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
67	22	18	22	10	27	25	00	00	00	00	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
68	22	18	22	20	18	00	00	00	1.	17	00	40	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
69	00	00	00	00	00	00	22	20	00	17	00	20	00	00	25	14	00	00	13	25	00	00	00	00	00	00	00
70	22	18	22	00	18	00	00	00	00	00	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
71	22	18	22	00	18	00	00	00	00	00	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
72	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
73	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
74	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
75	00	00	20	00	20	00	00	00	00	00	20	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
76	22	18	22	10	27	25	00	00	00	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
77	00	00	11	20	09	00	00	00	00	00	00	00	00	00	25	00	00	00	00	00	00	11	20	00	00	00	00
78	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
79	00	00	11	00	18	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
80	1.	89	13	00	11	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
81	89	1.	11	00	09	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
82	13	11	1.	00	33	00	00	00	00	00	00	00	00	33	00	00	00	14	00	00	00	14	00	00	00	00	00
83	00	00	00	1.	10	33	50	00	00	00	11	25	00	00	00	14	00	25	00	25	00	00	25	00	00	00	00
84	11	09	33	10	1.	00	00	00	00	00	20	00	00	00	00	00	00	00	00	00	00	00	20	00	00	00	00
85	00	00	00	33	00	1.	00	00	00	00	25	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
86	00	00	00	50	00	00	1.	40	00	17	00	20	00	33	33	33	00	20	29	50	00	00	00	00	00	00	00
87	00	00	00	00	00	00	40	1.	00	50	00	50	00	50	1.	33	00	25	40	50	00	00	00	00	00	00	00
88	00	00	00	00	00	00	00	00	1.	1.	00	1.	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
89	00	00	00	00	00	00	17	50	1.	1.	00	60	00	00	50	33	00	25	20	50	00	00	00	00	00	00	00
90	00	00	00	11	20	25	00	00	00	1.	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
91	00	00	00	25	00	00	20	50	1.	60	00	1.	00	00	50	33	00	25	20	50	00	00	00	00	00	00	00
92	00	00	00	00	00	00	00	00	00	00	00	1.	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
93	00	00	00	00	00	00	33	50	00	00	00	00	1.	50	00	00	00	00	33	50	00	00	00	00	00	00	00
94	00	00	33	00	00	00	33	1.	00	50	00	50	00	50	1.	67	00	1.	50	67	00	25	00	00	00	00	00
95	00	00	00	14	00	00	33	33	00	33	00	33	00	00	67	1.	00	67	40	50	00	00	00	00	00	00	00
96	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.	1.	00	00	00	00	00	00	00	00	00
97	00	00	00	25	00	00	20	25	00	25	00	25	00	00	1.	67	1.	1.	20	50	00	00	00	00	00	00	00
98	00	00	14	00	00	00	29	40	00	20	00	20	00	33	50	40	00	20	1.	25	00	00	00	00	00	00	00
99	00	00	00	25	00	00	50	50	00	50	00	50	00	50	67	50	00	50	25	1.	00	00	00	00	00	00	00
100	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.	1.	00	00	00	00	00
101	00	00	14	00	00	00	00	00	00	00	00	00	00	00	00	25	00	00	00	00	1.	1.	00	00	00	00	00
102	00	00	00	25	20	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.	00	00	00	00
103	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.	00	00	00
104	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.	00	00
105	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.	00
106	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1.

THE DEPARTMENT IN A FORMAL ORGANIZATION DATA

Subjects' recall lists for interviews 1 and 2 are identified
by subject number. Recalls proceed from left to right,
wrapping onto next line if necessary. Numbers in recall
lists represent persons. Self-mentions and intrusions are
not included in these lists. Subjects 1, 9, and 11 had
locationally oriented recalls in the first interview.
Subjects 1, 3, and 9 had locationally oriented recalls in
the second interview.

Interview 1

```
1      2   14    8    9   11   18    1    3   12    6    4   15   13
       7   22   23   20   10    5

2     11    1    9   18    2    8   14   16    4   15    6   13   23
      22   20    3

3      6   18    3   12    1   11    4   15   16   13    2    8   14
      22   23   19   21    7

4      6   14    7   12    1    9   11   13    4    3   15   22   23
       1    8    2

5      6   18    3    9   12    1   16   14    2    8   15    4    7
      13   20   23    5

6     18    1    9   12   11    6    4   13    2   14    8   16
       7    3    5   17

7     18    2    3    1   12   11    9    8   14    7    4   13   17
       5   15   16   22   23   20   10

8      6   18    2   11   12    1    9    3   16   13   15   23   20
      22    5

9     14    8    9   11   18    1    3   12    6   13   16    7

10     6    5    9   11   12    3   18   14    2   16    4   13   10
       1   15    8

11     4    6   15   12    3    1   18   11    9   16    2    7    5
      13   22

12     4   13   15    3   11    9   12    6    2   14   16    7   23
      20   18

13     6   18    1   11    9    4   15   12    3   16    8    2   13    7
```

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Interview 2   <u>a</u> by subject number indicates alphabetically
                 directed recall

1	2	14	8	9	11	18	1	3	12	6	15	13	4
	7	22	23	20	5	17						
2<u>a</u>	15	11	7	8	2	6	4	18	1	13	23	22	20
	3	16	9	5								
3	6	18	12	3	1	11	8	16	14	4	5	7	15
	13											
4<u>a</u>	11	4	8	2	3	15	14	1	12	22	9	7	16
	23	13										
5<u>a</u>	18	6	15	4	7	16	14	9	12	1	13	23	20
	4	3										
6	6	18	1	9	11	16	14	2	4	13	7	12	3
	5											
7<u>a</u>	15	5	14	16	2	8	11	18	17	20	1	22	12
	9	3	7	10	23	4	13					
8<u>a</u>	14	2	16	3	18	6	1	12	15	13	22	23	20
	18	11	9	7	8	16						
9	14	16	8	9	11	18	1	3	12	6	4	15	13
	23	7										
10	6	4	20	18	12	1	9	11	13	2	16	14	8
	15	22	23									

Translation between subject and person numbers

Subject number	Person number
1	16
2	12
3	9
4	18
5	11
6	15
7	6
8	4
9	2
10	7
11	14
12	22
13	23

Persons classified by gender

Males: 1 10 12 17 23

Females: 2 3 4 5 6 7 8 9 11 13 14 15 16 18 19 20 21 22

Persons classified by status (1 = highest, 5 = lowest)

1: 6

2: 18 2 3 5 17

3: 11 9 12 1 14 8 7

4: 15 13 4 16

5: 19 20 21 22 23 10

Persons classified by first letter of first name

B: 3 19

C: 5 11 15

D: 14

F: 16

G: 20

H: 2 8

J: 4

K: 7 17 18

L: 6 10

R: 1

S: 9 12 21 22

T: 23

W: 13

Ego rankings for work (rows = subjects, columns = persons, cell values = ranks [the rankings a subject assigned to persons]). "1" indicates ranking for self, and "-9" indicates that the subject did not recognize that person.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	14	2	3	11	16	7	6	5	12	20	15	13	10	4	8	1	21	9	-9	19	-9	17	18
2	12	19	3	6	15	7	8	18	4	21	13	1	11	14	5	9	20	2	-9	17	-9	10	16
3	8	18	3	11	15	7	10	14	1	23	5	6	13	9	4	12	16	2	22	19	21	17	20
4	6	15	5	11	10	3	12	14	2	17	7	4	16	13	8	9	21	1	-9	18	-9	19	20
5	23	13	9	5	14	7	6	15	2	22	1	8	12	10	4	11	20	3	21	19	18	17	16
6	6	15	4	5	19	3	20	22	8	23	7	9	14	21	-9	11	18	10	17	16	-9	12	13
7	15	2	5	10	13	1	8	11	7	22	17	16	14	6	4	12	9	3	20	21	-9	18	19
8	11	14	2	1	22	4	17	18	13	21	10	8	12	16	3	15	23	9	-9	7	-9	8	18
9	13	1	10	9	16	5	6	8	12	19	14	15	4	3	7	2	20	11	-9	-9	-9	18	17
10	9	5	12	-9	13	4	1	8	11	3	6	10	7	2	16	15	23	14	-9	18	-9	17	19
11	11	2	5	13	22	6	3	4	14	16	10	12	9	1	15	7	23	8	21	20	18	17	19
12	9	10	13	2	18	12	6	19	14	20	15	7	5	16	4	8	-9	11	-9	17	-9	1	3
13	5	15	14	3	17	16	7	18	11	-9	8	6	13	12	4	10	-9	9	-9	-9	-9	2	1

Ego rankings for socializing (rows = subjects, columns = persons, cell values = ranks [the rankings a subject assigned to persons]). "1" indicates ranking for self, and "-9" indicates that the subject did not recognize that person.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	11	2	5	9	16	15	6	14	8	21	12	10	7	4	3	1	20	13	-9	19	-9	17	18
2	7	15	4	16	14	6	8	5	3	21	11	1	13	10	12	9	20	2	-9	19	-9	17	18
3	14	16	4	15	9	8	6	7	1	20	2	5	11	12	10	13	18	3	22	21	23	17	19
4	9	7	2	5	8	3	10	14	1	19	5	4	13	12	11	6	18	-9	-9	17	-9	20	16
5	23	13	8	12	5	14	4	15	2	22	1	10	11	6	7	9	20	3	21	19	18	17	16
6	15	9	7	6	5	12	8	18	10	19	11	14	3	16	-9	4	17	13	21	23	-9	20	22
7	6	8	3	16	13	1	14	12	4	21	7	5	17	9	11	10	15	2	20	22	-9	18	19
8	11	12	9	1	5	15	7	3	10	22	14	17	6	2	4	13	23	16	-9	19	-9	8	18
9	11	-9	17	1	8	13	3	19	12	16	9	10	5	6	7	2	18	4	-9	-9	-9	14	15
10	14	9	16	13	4	17	1	10	5	11	6	12	2	3	7	8	23	15	-9	18	-9	19	20
11	11	7	4	2	14	13	5	3	9	15	8	10	17	1	16	6	23	12	21	19	20	18	22
12	8	13	11	2	17	18	5	6	12	20	15	7	4	16	3	10	-9	14	-9	19	-9	1	9
13	9	11	10	3	15	16	7	-9	12	-9	8	6	4	17	5	13	18	14	-9	-9	-9	2	1

Subjects' boss perceptions (rows = subjects, columns = persons, cell values = person number for person's boss as perceived by row subject). "-9" indicates that the subject did not recognize that person.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	18	6	6	3	6	24	2	2	18	7	18	18	6	6	6	2	6	6	-9	4	-9	4	4
2	18	6	6	3	6	24	6	2	18	7	18	18	6	2	6	2	6	6	-9	4	-9	4	4
3	18	6	6	3	-9	24	6	2	18	7	18	18	3	2	6	2	6	6	4	4	4	4	4
4	18	6	6	3	6	24	2	2	18	7	18	18	3	6	6	2	6	6	-9	3	-9	3	3
5	18	6	6	3	6	24	6	2	18	7	18	18	3	2	6	2	4	6	4	4	4	4	4
6	18	6	6	3	6	24	2	2	18	7	18	18	6	2	6	2	6	4	4	4	4	4	4
7	18	6	6	3	6	24	2	2	18	7	18	18	6	2	6	2	6	6	25	4	-9	4	4
8	18	6	6	3	6	24	6	2	18	7	18	18	6	2	6	2	6	6	-9	3	-9	3	3
9	18	6	6	3	6	24	2	2	18	7	18	18	6	2	6	2	6	6	-9	-9	-9	3	3
10	18	6	18	6	6	24	2	2	18	7	18	18	6	2	6	2	6	6	3	3	3	3	3
11	18	6	6	3	6	24	2	2	18	7	18	18	3	2	6	2	6	6	3	3	3	3	3
12	18	6	6	3	6	24	2	2	18	7	18	18	3	2	6	2	-9	6	-9	4	-9	4	4
13	18	3	24	6	-9	24	6	3	18	-9	18	18	6	6	6	6	-9	24	-9	4	-9	4	4

Aggregated perceived work proximity matrix. Rows and columns refer to persons, and cell values represent proportions with the decimal points omitted. "1." indicates a value of unity.

```
    1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

 1  1. 19 48 16 27 38 15 12 84 15 87 87 14 13 23 13 08 82 15 10 21 16 16
 2  19 1. 21 10 05 20 43 68 19 41 19 24 16 70 13 86 05 24 09 08 14 10 10
 3  48 21 1. 17 14 48 20 19 49 20 51 52 13 21 29 18 09 52 15 11 21 17 17
 4  16 10 17 1. 05 17 11 07 16 10 16 16 33 09 45 10 07 16 57 83 1. 90 90
 5  27 05 14 05 1. 17 06 05 24 07 24 24 08 05 10 05 13 24 04 03 09 05 05
 6  38 20 48 17 17 1. 18 19 35 18 38 38 19 20 35 16 19 35 15 11 21 17 17
 7  15 43 20 11 06 18 1. 43 15 88 15 15 21 46 15 45 06 15 12 10 21 11 11
 8  12 68 19 07 05 19 43 1. 12 41 12 12 14 82 11 70 05 12 09 05 14 07 07
 9  84 19 49 16 24 35 15 12 1. 15 93 89 14 13 23 13 08 90 15 10 21 16 16
10  15 41 20 10 07 18 88 41 15 1. 15 15 23 43 13 41 07 15 12 07 21 10 10
11  87 19 51 16 24 38 15 12 93 15 1. 90 14 13 23 13 08 87 15 10 21 16 16
12  87 24 52 16 24 38 15 12 89 15 90 1. 14 13 23 13 08 86 15 10 21 16 16
13  14 16 13 33 08 19 21 14 14 23 14 14 1. 15 38 16 16 14 29 26 57 33 33
14  13 70 21 09 05 20 46 82 13 43 13 13 15 1. 12 73 05 13 09 05 14 09 09
15  23 13 29 45 10 35 15 11 23 13 23 23 38 12 1. 13 15 23 31 32 59 45 45
16  13 86 18 10 05 16 45 70 13 41 13 13 16 73 13 1. 05 13 09 08 14 10 10
17  08 05 09 07 13 19 06 05 08 07 08 08 16 05 15 05 1. 08 07 09 13 07 07
18  82 24 52 16 24 35 15 12 90 15 87 86 14 13 23 13 08 1. 15 10 21 16 16
19  15 09 15 57 04 15 12 09 15 12 15 15 29 09 31 09 07 15 1. 48 80 57 57
20  10 08 11 83 03 11 10 05 10 07 10 10 26 05 32 08 09 10 48 1. 1. 86 86
21  21 14 21 1. 09 21 21 14 21 21 21 21 57 14 59 14 13 21 80 1. 1. 1. 1.
22  16 10 17 90 05 17 11 07 16 10 16 16 33 09 45 10 07 16 57 86 1. 1. 94
23  16 10 17 90 05 17 11 07 16 10 16 16 33 09 45 10 07 16 57 86 1. 94 1.
```

Aggregated socializing proximity matrix. Rows and columns refer to persons. Cell values represent proportions with decimal points omitted. "1." indicates a value of unity.

```
    1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

 1  1. 14 31 13 17 35 14 09 27 02 27 37 13 12 13 12 01 31 02 01 00 07 06
 2  14 1. 16 16 12 11 23 26 16 04 16 16 22 33 20 74 01 16 02 01 00 07 06
 3  31 16 1. 20 18 34 17 20 41 04 41 48 17 24 15 14 01 49 02 01 00 07 06
 4  13 16 20 1. 15 10 18 24 13 08 13 15 25 26 26 14 05 13 10 17 17 21 19
 5  17 12 18 15 1. 17 17 15 15 02 15 15 17 16 21 12 01 15 02 01 00 04 03
 6  35 11 34 10 17 1. 11 08 29 02 27 30 10 11 12 11 01 35 02 01 00 06 04
 7  14 23 17 18 17 11 1. 19 16 08 16 17 72 26 31 22 01 14 02 01 00 07 06
 8  09 26 20 24 15 08 19 1. 21 06 21 22 16 52 13 27 01 14 02 01 00 03 01
 9  27 16 41 13 15 29 16 21 1. 04 95 35 15 14 15 14 01 62 02 01 00 07 06
10  02 04 04 08 02 02 08 06 04 1. 04 04 14 06 12 04 00 04 00 08 00 08 06
11  27 16 41 13 15 27 16 21 95 04 1. 33 15 14 15 14 01 57 02 01 00 07 06
12  37 16 48 15 15 30 17 22 35 04 33 1. 17 16 15 14 01 40 02 01 00 07 06
13  13 22 17 25 17 10 72 16 15 14 15 17 1. 23 40 20 01 15 02 08 00 13 11
14  12 33 24 26 16 11 26 52 14 06 14 16 23 1. 20 35 01 14 02 01 00 06 04
15  13 20 15 26 21 12 31 13 15 12 15 15 40 20 1. 18 01 15 02 10 00 15 13
16  12 74 14 14 12 11 22 27 14 04 14 14 20 35 18 1. 01 14 02 01 00 06 04
17  01 01 01 05 01 01 01 01 01 00 01 01 01 01 01 01 1. 01 09 06 17 05 05
18  31 16 49 13 15 35 16 14 62 04 57 40 15 14 15 14 01 1. 02 01 00 07 06
19  02 02 02 10 02 02 02 02 02 00 02 02 02 02 02 09 02 1. 30 17 25 25
20  01 01 01 17 01 01 01 01 01 08 01 01 08 01 10 01 06 01 30 1. 25 26 26
21  00 00 00 17 00 00 00 00 00 00 00 00 00 00 00 17 00 17 25 1. 17 17
22  07 07 07 21 04 06 07 03 07 08 07 07 13 06 15 06 05 07 25 26 17 1. 33
23  06 06 06 19 03 04 06 01 06 06 06 06 11 04 13 04 05 06 25 26 17 33 1.
```

Location distance matrix. Rows and columns refer to
persons. Cell values represent shortest walking distances
between persons' offices/cubicles as measured (in
millimeters) from the department blueprint. The "-9" values
indicate a row or column person who did not have an office
in the main office area.

	1	2	3	4	5	6	7	8	9	10	11	12
1	0	130	95	218	252	231	62	126	113	-9	99	133
2	130	0	155	104	185	164	72	87	100	-9	132	169
3	95	155	0	195	196	175	97	203	190	-9	176	76
4	218	104	195	0	161	140	170	177	190	-9	222	139
5	252	185	196	161	0	67	255	258	271	-9	303	140
6	231	164	175	140	67	0	234	237	250	-9	282	119
7	62	72	97	170	255	234	0	126	139	-9	143	135
8	126	87	203	177	258	237	126	0	29	-9	61	241
9	113	100	190	190	271	250	139	29	0	-9	48	247
10	-9	-9	-9	-9	-9	-9	-9	-9	-9	0	-9	-9
11	99	132	176	222	303	282	143	61	48	-9	0	214
12	133	169	76	139	140	119	135	241	247	-9	214	0
13	133	167	76	143	144	123	135	241	247	-9	214	26
14	141	54	176	144	225	204	93	49	62	-9	94	234
15	237	170	181	146	73	22	240	243	256	-9	288	125
16	126	87	203	177	258	237	126	0	29	-9	61	241
17	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
18	37	149	114	237	271	250	81	107	94	-9	80	152
19	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
20	230	116	207	19	173	152	182	189	202	-9	234	151
21	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
22	230	116	207	19	173	152	182	189	202	-9	234	151
23	230	116	207	19	173	152	182	189	202	-9	234	151

	13	14	15	16	17	18	19	20	21	22	23
1	133	141	237	126	-9	37	-9	230	-9	230	230
2	167	54	170	87	-9	149	-9	116	-9	116	116
3	76	176	181	203	-9	114	-9	207	-9	207	207
4	143	144	146	177	-9	237	-9	19	-9	19	19
5	144	225	73	258	-9	271	-9	173	-9	173	173
6	123	204	22	237	-9	250	-9	152	-9	152	152
7	135	93	240	126	-9	81	-9	182	-9	182	182
8	241	49	243	0	-9	107	-9	189	-9	189	189
9	247	62	256	29	-9	94	-9	202	-9	202	202
10	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
11	214	94	288	61	-9	80	-9	234	-9	234	234
12	26	234	125	241	-9	152	-9	151	-9	151	151
13	0	234	125	241	-9	152	-9	155	-9	155	155
14	234	0	210	49	-9	140	-9	156	-9	156	156
15	125	210	0	243	-9	256	-9	158	-9	158	158
16	241	49	243	0	-9	107	-9	189	-9	189	189
17	-9	-9	-9	-9	0	-9	-9	-9	-9	-9	-9
18	152	140	256	107	-9	0	-9	249	-9	249	249
19	-9	-9	-9	-9	-9	-9	0	-9	-9	-9	-9
20	155	156	158	189	-9	249	-9	0	-9	0	0
21	-9	-9	-9	-9	-9	-9	-9	-9	0	-9	-9
22	155	156	158	189	-9	249	-9	0	-9	0	0
23	155	156	158	189	-9	249	-9	0	-9	0	0